# THE TEACHING OF *Science* IN TROPICAL PRIMARY SCHOOLS

*By* E. D. JOSEPH

OXFORD UNIVERSITY PRESS

An understanding of Science is vital not only to expert scientists but to ordinary men and women as well. It is as necessary for them to know what scientists try to do and how they try to do it as to be familiar with scientific facts and principles.

This series of books has been designed to advise and help teachers of Science, particularly those working in the rapidly-developing tropical countries, to give their pupils this understanding through a view of science as a whole.

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*by*

E. D. JOSEPH

*Being* VOLUME I *of the*
UNESCO HANDBOOKS
ON THE TEACHING OF SCIENCE
IN TROPICAL COUNTRIES
*General Editor: F. Smithies*





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# General Introduction

Scientific discoveries, and their applications in industry, communications, agriculture, medicine and war, have caused great changes in the lives and habits of most of mankind during the last 150 years. Men's ways of thought are not yet accustomed to this change.

Because of the destructive power of some scientific inventions, many men have lost faith in the future of mankind; because of the marvellous power of other scientific inventions to increase the well-being of mankind, many men have expected Science to find an answer to all life's problems. Both of these views of Science show a misunderstanding of what Science is and what scientists can or cannot do. How can such misunderstandings be prevented?

It is not enough to train expert scientists; they are necessary, but it is equally necessary that ordinary folk should know what scientists try to do and how they try to do it. Before they can understand the scientists' work, non-scientists must first learn what Science is. For this, a knowledge of scientific facts and principles is not as important as an understanding of Science and the methods used in its study. And this understanding of Science must become a part of men's everyday life and thought.

Understanding comes through education; but the understanding of Science must not remain merely an aim of education: it must become part of it. In schools, isolated courses in one or another aspect of science must be replaced by a view of Science as a whole, and of its part in learning.

That is the basis of the project, in this series of books, to advise and help teachers of Science. The emphasis is put on methods of teaching and lines of approach to the subject matter, rather than on the content of a syllabus. It is hoped that, by the use of good methods, the teacher will be able to lead his pupils

towards an appreciation of scientific methods and an understanding of Science. Through sound education, not only will the few receive the basic training that will fit them for specialization later, but the many will grow up with an intelligent grasp of Science and its significance in their social and economic life.

## THE SCOPE OF THE SERIES

There are ten volumes in the series, designed specially for Science teachers in tropical areas and countries that are not yet highly organized and industrialized, and where the applications of science are not yet apparent in the daily life of all citizens:—

I The Teaching of Science in Tropical Primary Schools
II The Teaching of Rural Science in Tropical Primary Schools
III The Teaching of Health Science in Tropical Primary Schools
IV The Teaching of Home Science in Tropical Primary Schools
V The Teaching of Arithmetic in Tropical Primary Schools
VI The Training of Primary School Science Teachers
VII The Teaching of General Science in Tropical Secondary Schools
VIII The Teaching of Physics in Tropical Secondary Schools
IX The Teaching of Chemistry in Tropical Secondary Schools
X The Teaching of Biology in Tropical Secondary Schools

Volume I is concerned with the teaching of Science to children in the age-group 6–12 approximately, who are receiving their first formal education. It is designed for students in teacher-training colleges and practising teachers in Primary

Schools. They are shown how to make the most of the children's natural interests.

Volumes II, III and IV also are written mainly for the benefit of the Primary School teacher. They treat Science at the same level as Volume I, but from different aspects. Thus, Volume II is of especial value to teachers in rural schools: it does not give instruction about the teaching of 'Farming' or 'Agriculture', but uses these activities to give practical examples of scientific methods and principles in action. Similarly, in Volume III the importance of Health is the theme of Science teaching. The book will help any teacher, and will be of particular use to those in places where great efforts are being or should be made to raise standards of health. Volume IV associates the teaching of Science with life in the home, as the basis of a Science course for girls.

Volume V deals with the fundamentals of Arithmetic as an essential component of Science.

Volume VI is concerned with the training of teachers who are to give the science lessons in Primary Schools, and who, it is hoped, will adopt the methods suggested to them in Vols. I–V.

Volume VII carries the teaching of General Science to the earlier years of a secondary course: 4–5 years in the age-group 11–18 approximately. It shows how the work can be regarded both as a course of educational value for its own sake and also as a foundation for further studies. It gives full information on laboratory design and organization, minimum equipment, and maintenance.

Volumes VIII, IX and X discuss the teaching of the three branches of Science usually taught in the higher classes of Secondary Schools. The place and treatment of these subjects in junior work also is considered briefly. The chief aim of these three volumes is to assist the teacher of students who are beginning to specialize, probably with a university career in view, i.e. those who are undertaking 'sixth-form' or 'scholarship' or 'first-year undergraduate' studies.

## THE AIMS OF THE SERIES

Thus, the intention of this series of books may be summarized as follows:—

(*a*) To help teachers of Science to realize the importance of their work in the community; to help them to guide their pupils to an understanding of the significance of everyday occurrences and experience; and so to educate them to take an intelligent interest in social and economic affairs and to be useful members of their community.

(*b*) To show how Science instruction can be organized as a continuous whole, in accordance with modern views of co-ordinated teaching, and how it can be adapted to meet any special requirements of a particular type of school.

(*c*) To suggest a comprehensive scheme of teaching based on sound educational and psychological principles.

(*d*) On the basis of the practical teaching experience of the authors and the general editor and their advisers, to outline the content of Science teaching from the Primary to the Pre-University level.

This series originates in the need, so often expressed to the United Nations Educational Scientific and Cultural Organization, especially by those responsible for education in tropical countries, for more and better science teaching in Primary and Secondary Schools. These educationists share world-wide opinion that training in Science is essential to modern education, to the improvement of health and living conditions and the promotion of agriculture and industry. In response to their appeal Unesco conceived the plan and the method of presentation of the series and subsidized the preparation of the ten manuscripts. Responsibility for choosing the authors and the general editor and for the cost of publication was undertaken by the Oxford University Press in agreement with Unesco.

# Preface to Volume I

Chapters I–III (Part One) of this book draw attention to the general principles and practice of Science teaching at the elementary stage. Chapters IV–IX (Part Two) give day-to-day guidance for the teaching of a six-year course to children in the approximate age-group 6–12. (This does not include kindergarten or infant-class work.)

The reader will find help in:

(i) the selection of material for an elementary Science course;

(ii) the planning of practical work and the performance of experiments, for there are many practical hints and instructions.

Most important, however, is the emphasis on method. The book shows HOW Science should be taught, how to plan and prepare the work, how to carry it out in classroom, garden, village or town, and the district around the school. It is not a text-book to supply scientific facts needed in the lessons, although many facts are mentioned to suggest lines of approach or ways of reasoning. Nor is it a list of prepared lessons. The author does not try to do the teacher's work for him, but suggests how the teacher can best do his own preparation. Scientific methods and good teaching methods thus receive equal emphasis.

The author wishes to record her indebtedness to Messrs. F. Daniel, G. R. Dent, C. T. Eddy and F. E. Joselin for help and criticism.

*May* 1953 E. D. JOSEPH

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# PART I

## CHAPTER I

## Preparation for Science Teaching

### HOW TO USE THIS BOOK

The teacher should make himself thoroughly familiar with Part I, and should keep the various points in mind throughout all his work. If he has not been trained to careful observation, he should first train himself in the manner described. Part II, which covers the treatment of a scheme of work, begins with *an outline of the grouping of subject matter*. This is a summary of the topics considered, but it is NOT a syllabus. The subjects for each year are not arranged in an exact order of study, as will be explained. Arrangement under the headings 'Living Things', 'Earth and Universe' and 'Matter and Energy' is a general guide and not a rigid system. The outline has been carefully planned to serve as a *basis* for the development of general science syllabuses, for different countries and various localities, according to their needs. A detailed syllabus can be made only by those 'on the spot', the educationists and teachers who know local conditions: a syllabus *must* be related to the *local* climate, plants and animals, agriculture, crafts and industries, etc. The teacher must first examine the syllabus he has to use in his school; then he can refer to the outline in this book and quickly find the topics he wants. Even if they are given for a different year's work in the syllabus, he can easily see how they fit into the general scheme.

### THE ASSIGNMENT OF TEACHING PERIODS

It is impossible to give any general rule or statement. However, the science course includes the work which has often been

taught as separate subjects such as 'Hygiene', 'Nature Study', 'Gardening', etc., and as a part of 'Geography'; hence it would not be unreasonable to allot:

2 classroom and 2 outdoor periods per week in each of the first three years, and

4 classroom and 2 outdoor periods per week in each of the last three years.

It does not matter whether a lesson is called Geography or Science, as long as it is taught properly in its proper context. Knowledge does not consist of separate departments, and it is quite a good thing if there is no strict division into the different subjects taught in school.

In many countries general elementary science has not been taught in the Primary Schools. Certain science subjects have been included in the curriculum, for example Nature Study, Hygiene, Gardening and, sometimes, Agriculture. A more recent development is the General Science course, which, while including much nature study, has a wider scope. What reasons are there for such a change? Why should young children be taught science? What do we mean by science? The following paragraphs give brief answers to these questions.

### THE SUBJECT MATTER OF SCIENCE

We might sum up the subject matter of science by saying that it includes The Universe, The World Around Us, and Ourselves. Long before reading and writing were invented, man began to study the heavens and the living and non-living things around him. Every little child repeats some part of this process, making his own observations and experiments as far as he is able. But neither primitive man nor the young child are scientists; they may investigate some of the subject matter of science, but they do not approach their problems in the same way that the scientist does.

## THE METHODS OF SCIENCE

The scientist has a characteristic attitude of mind and way of working. In simple terms this is how he sets to work. First he *observes*: whether he is a farmer, a doctor or a science research worker, he begins by watching the things in which he is particularly interested; he *thinks* about what he sees, and a *problem to be solved* occurs to him. Further thought suggests, say, two *possible solutions* to the problem. Next he thinks out and performs *experiments to test the truth* of his hypotheses, as these unproved ideas are called. From the *recorded results* of these experiments he may accept one solution and reject the other, or he may find that the results show that both his hypotheses are unsatisfactory; if this happens he must make a fresh start, for he is seeking the truth and must keep an open mind, ready to consider new facts and to test them by new experiments.

Thus we see that *science is not only knowledge about the universe, it is also a way of obtaining knowledge.*

What has this to do with young children of Primary School age? A great deal. First, notice that the subject matter of science, if suitably chosen, consists of just those things that all children want to know. In the past much school work has been criticized as being out of touch with the children's home life, but science teaching should be so firmly based on the actual environment that it adds meaning and interest to the life of the home and the community, and links the school with the home. Throughout this book there are suggestions as to how the teaching can be related to a particular environment, and it is emphasized that details of such adaptation of the general scheme to local conditions must be worked out separately for every area. Secondly, a great deal of the value of science as a school subject comes from the attitude of mind and way of working which have been described as the Method of Science. The chief aim is not to produce scientists, but to try to make better citizens. Science

should form part of the education of all children, both boys and girls: they will be better citizens if they are observant and can give accurate accounts of what they see. If they realize that, by practical means, the truth of statements can usually be tested, they will be less easily led away by unsound arguments in speech or in print. If we wish to produce this kind of citizen, it is no use planning science lessons simply as opportunities for imparting information; we must realize that HOW we teach science is just as important as WHAT we teach, and we must take as our maxim: better a little science by good methods than many facts about science by poor methods.

## REASONS FOR THE TEACHING OF SCIENCE IN PRIMARY SCHOOLS

These reasons can be briefly summarized as follows:—

1. *Science starts from the children's natural interests and normal activities*; it leads to further knowledge of the things around them, and encourages them to discover and experiment for themselves.

2. *Science keeps the children in touch with their environment*, forming a link between life at home and life at school.

3. *Science has practical value*; it points the way to improvements in agriculture, hygiene, housing and sanitation. Young people who have learnt some science are better equipped for their work in the world, whether this lies in the home, on the farm, or in business.

4. *Science gives valuable mind-training*. It should train the children:

- to observe carefully;
- to make accurate reports on what they observe;
- to realize the importance of asking for and considering evidence before coming to conclusions;
- to realize the value of trying by practical means, such as experiments, to test the truth of a statement.

5. *Science helps to train good citizens.* We live in a world which is changing very rapidly. Our children need some knowledge of science, if they are to understand the modern world, which depends so much on scientific discoveries. They need well-disciplined minds, if they are to be good citizens of a democratic country.

6. *Science helps to remove superstition and fear of the unknown.*

## THE TEACHER OF SCIENCE

If you think about what has been said of the meaning of science and its value as a school subject, you will realize that some special preparation and training are desirable before you start teaching science.

It is true that any teacher can learn and pass on a certain amount of information about science, but he will not be able to give the right outlook or the mind training, which are part of science teaching, unless he himself has the right attitude of mind. In Training Colleges there is likely to be special preparation for science teaching, but some teachers who are already qualified may wish to equip themselves better for this work. First of all, do not be afraid to start because you have only a limited knowledge of the subjects touched on in the course. Enthusiasm and willingness to learn will count for much; in fact the teacher with plenty of initiative and enthusiasm will prove more successful, eventually, than one who starts with more factual knowledge, but presents it by dull, routine methods. The outlook of the teacher is more important than the extent of his knowledge.

### *Special qualities and skills needed for Science Teaching*

I. *Enthusiasm for discovery* is found in children, and to keep it alive the teacher must be a discoverer himself, ready to join in watching and considering the ways of living things, the weather, the stars, a machine, or whatever else is the subject of

interest. 'Discoveries' are not likely to be new in the sense that nobody has recorded them before, but if anyone finds out something by his own observation, then for him it is a discovery, which will have more importance than what he has only read or heard about. When a little child brings you some familiar object which is new to him and therefore a discovery, try to enter into his enjoyment; never discourage him by lack of interest or a superior attitude, which makes him feel that his interesting find is of no importance.

II. *The habit of observation.* Careful observation is the foundation of all science, and those who teach science need to practise this habit. Observation means noticing, that is, seeing and taking note of; the note may be in the mind, a mental note, or we may go further and write a few sentences or make a sketch, but by some means we make a record of what we have noticed. This is where observation differs from 'seeing'; the observant person will actually see more than his less observant companion: he will also remember what he has seen, because his mind has been active and taken note of the things he saw. Therefore, if you learn to observe, you learn also to make accurate reports of what you see.

III. *Accurate reporting.* A good memory is the starting-point of accurate reporting, but memory alone is not enough. There are some people who, when asked to give an account of an incident they have witnessed, remember many details, but they use their imaginations when recounting the story. Perhaps they have a strong desire to prove that somebody is innocent, so that, while they think they are telling the truth, they really give a false picture. In science we try to free ourselves from prejudice and to report exactly what we see or hear, even though it is not what we wanted or expected. Again, reporting may be inaccurate through inability to estimate numbers, distances or sizes, or through failure to appreciate small colour differences. Skill in

these matters is almost entirely a matter of practice. Teachers can try some of the exercises given here, and then they will find opportunities, when teaching, for training their pupils in the same way.

*Exercises in observation and reporting*. When estimating measurements it is important to be honest with yourself, and to write down your guesses before checking by actual measurement. Such exercises are much more amusing if you find a friend and compete against him.

1. *Distance*. Estimate the lengths of any small objects, in inches or feet and inches. Check with a foot-rule. Estimate longer distances, measured either in yards and feet, or in paces: e.g. sizes of rooms, sizes of buildings, distance between buildings. Check by measuring your stride and pacing, or with a yard-stick.
2. *Number*. Provide a pile of beans, stones or other small objects. Take a few and place them on the table; can you estimate immediately, without counting, how many there are? Do this for varying numbers.

   When you see a collection of any similar objects, practise guessing the number, and check afterwards by counting: e.g. the number of books on a shelf, cows in a herd, lorries in a lorry-park, bananas in a bunch, pupils in a new class, people at a meeting. Accuracy in estimating numbers will prevent that wild exaggeration which often occurs in eye-witness accounts.
3. *Shape*. A few adjectives denoting shape (round, oval, oblong, square, etc.) will be enough for ordinary purposes. An accurate verbal description of shape is often difficult, and it is far more important to be able to make quick sketches giving the general shape of an object. For this purpose, train yourself to take note of proportion, especially of the relation of width to length. Practise drawing outlines of leaf shapes. Note where the

widest point comes; with the end of the pencil measure how many times the width is contained in the length; now make the sketch quickly with firm lines. Check your drawing for proportion. Make another sketch of the same leaf giving it a different size, but keeping the proportions correct. When drawing larger and more distant objects shut one eye, hold your pencil at arm's length, and 'measure' the width and length before beginning. For instance, in making the sketch of the tree shown in Figure 1, three measurements were taken: height of trunk; greatest width of crown; greatest height of crown. The results show that, in this case, the trunk is slightly longer than the crown width, and the crown height is half its width. Such mechanical aids to drawing in proportion may be useful to teachers who have not a natural gift for drawing; those who have such a gift will reproduce correct proportions without trouble.

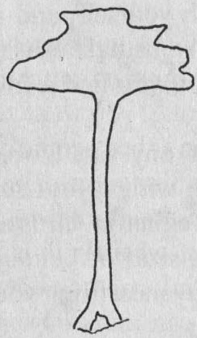

FIGURE 1.—Outline sketch of a tree: drawn to correct proportions

4. *Colour*. There are so many shades of colour that accurate verbal description is difficult. You can get practice in naming and describing different colour shades by attempting descriptions of birds and flowers.
5. *General*. Shut your eyes and see how accurately you can describe the room in which you are; it does not matter how familiar it is. Open your eyes and check your descripion.

Choose any two familiar objects such as two kinds of tree or crop-plant, two breeds of cow, two kinds of fish. From memory write down the differences between them. Observe the real objects and see what points you omitted or got wrong.

Select some subject which interests you and keep it under observation, making written notes and sketches. See if you can notice something of interest on your way to school every morning. If you live in a town and your chief interest happens to be in machines, make these your special study instead of some 'nature study' subject.

IV. *Seeking further knowledge*. Observation is not merely a useful habit, it is a means to an end. Once you start watching, and making notes, you are sure to begin thinking: you want to know more. You may *seek for information* from other people or from books. When doing so, ask yourself: 'Is this source of information reliable?' Try to check, by further observation, what people tell you. If you consult a book, find out whether it is written for your particular area, and whether the information does really refer to your particular problem. If you can think of some way of finding your own answer, you will be using the method of experiment.

V. To *draw correct conclusions from evidence* needs much practice. You will not expect children of Primary School age to go far with this. It has been shown that, up to 11 or 12 years of age, the child only uses logical thought in connexion with what he *does* himself. This fact has been recognized for many years in the teaching of Arithmetic to small children: all operations are taught concretely at first; reasoning comes afterwards. Similarly, the ideal way of teaching science to young children is by means of much practical work, which they carry out themselves. In this book it is recognized that such activity methods may not always be possible in schools where classes are large, and where the subject may be new to the teachers. You can, however, do much by encouraging children to *think* and to think sensibly about what they see; by making a habit, both in and out of lesson-time, of asking questions that are designed to help the children to use their minds; by getting away from the old-

fashioned notion that the object of all questions is to test whether the child remembers what he has been told. While gardening, or when out for an excursion, suitable questions stimulate the mind and arouse interest. A famous scientist, Aggassiz, used to tell his students: 'I shall never make you repeat what you have been told, but constantly ask you what you have seen for yourselves.'

We have seen that the teacher of science needs the spirit of discovery, the habit of observation, the ability to make accurate reports, enterprise in seeking for answers to problems, and some ability to draw conclusions from evidence. One more quality should be mentioned and that is *humility*. In many places in the past the teacher was regarded as the source of all information, the man who was never at a loss for an answer. Under this system the children expect *to be told* all they need to know; their part is to memorize the facts which the teacher gives them. He fears to admit ignorance, for he feels that he may lose the respect of his class if he says openly, 'I do not know.' This attitude may lead him into evasive, contradictory or untrue answers; worse still, it makes him discourage independent thought by his pupils, in order to prevent them asking awkward questions. He likes to keep to a few well-worn topics where he feels sure of his ground. Never be afraid to say, 'I do not know': it is folly to let children believe that you know more than a fraction of what has been found out about any subject. Near the end of a life-time of work and discovery, one of the greatest scientists said that he felt like a little child picking up stones on the shore of a great sea. When children ask questions that you cannot answer, take the line: 'I do not know,' or 'I am not sure, *but let us try to find out*.' If you and your class together succeed in finding the answer to even one of the children's questions, there will be an immediate increase of interest in the subject, and you will have gone a long way to developing that eager, inquiring mind which will help to make a good citizen.

*Trying to find answers to questions*

1. Consult books.
2. Ask somebody who has knowledge of the subject, e.g. a hunter, farmer, craftsman, or engineer. If necessary write the question down and wait until somebody, for example a visiting doctor, can be consulted.
3. Get the children to ask somebody whom they know.
4. Carry out a test or experiment with the class.

By such methods the class finds out that, although *you* do not know all the answers, they and you together can sometimes discover what they want to know. This kind of relationship between teacher and pupils is of fundamental importance. It is especially valuable because it does away with the fatally wrong idea that learning (or education) begins and ends in school. Let your pupils see you as an eager learner, so that they too may want to go on learning when they leave school.

In the later Primary years pupils should understand that there are many questions to which nobody knows the answers. Men of science are always looking for, and finding, better answers to questions about the world.

*The teacher's relationship to the community*

The good teacher knows and understands his pupil's background: he aims at knowing the home from which each child comes, so that he can understand special difficulties or unusual behaviour. He probably shares the life of the community, and so can draw illustrations for lessons from familiar objects and events. The teacher of science has a special responsibility for keeping in close touch with village or civic life; his subject matter is largely concerned with the immediate environment, and, since he cannot hope to know everything himself, he should enlist the help of all the reliable people he can find. He looks for co-operation from local craftsmen, hunters, farmers, fishermen, mechanics, those working in public services such as health, water-supply, sanitation, agriculture and forestry. Friendly rela-

tions with such people usually make them ready to answer questions and to allow the class to visit the workshop, farm, waterworks, etc.

In some places there are people, who, especially if they are illiterate, become suspicious of the teacher and his new ways. A teacher who disregards such people may be losing a great deal for himself and his pupils, because many of them, e.g. if they are hunters or farmers, often have a great wealth of knowledge about animals and plants, much of it accurate and valuable.

If you get two answers to a question, then is the time to see whether you and the class can find out which is correct. Children in the top classes should realize that some sources of information are not reliable, and that mistakes occur even in books.

In the course of discussions the children are sure to mention some common beliefs which are widely held, but are not true: e.g. that locust droppings grow into snakes, or that the chameleon gives a poisonous bite. The best kind of approach to these is to ask—'Are we sure this is true? How can we prove it? Has anybody actually *seen* this taking place? Did the person who told you see it, or was he told of it by someone else?' Take every opportunity of testing, by actual observation and experiment, the truth of statements of fact which you suspect to be incorrect.

So the teacher of science should be on friendly terms with the most varied types of people; he should gather information about local animals, plants, herbal medicines and crafts, from the men and women who really know, whether they are literate or illiterate. A well-disposed garage mechanic may help by giving odds and ends from old machines; the sanitary inspector may give advice on building a new incinerator; the manager of a saw-mill may allow an excursion to the mill and tell one of his men to explain the machinery and the uses of different kinds of timber. Thus, good relations between the teacher and the community will help in many practical ways. They will also ensure that school science gives new interest to the children's

life outside the school. The older pupils should be encouraged to help with improvements in the neighbourhood, and it is only when teachers are liked and trusted by those in authority in the village, that school children can help effectively with projects for the improvement of conditions in their village or town.

*The relationship between teacher and parents*

It is particularly important for the teacher and parents to be on good terms in places where the teachings of science include new ideas, which may be resented or distrusted by many parents. In matters relating to health, hygiene and diet, mothers and fathers are likely to be extremely conservative, so that some of the pupils see what they learn in school being disregarded at home. Great patience and tact are needed, lest the more old-fashioned parents accuse the school or the teacher of undermining their authority. Teachers must try to make time for visiting their pupils' homes. They should try to arouse the parents' interest in school work. Even educated parents often feel that what their children learn in school is no concern of theirs, while those who have not had school education often suppose schooling to be 'book-learning', which can have no meaning for them. As a result there is often a clear division in the children's minds between home-life and school-life. The teacher may try to enlist the parents' interest in the following ways:—

Whenever possible ask the children to bring information from home as a contribution to the next lesson. If you know a father or mother who has special skill in some matter relating to the science work, try to make use of this, either by seeking information from him, or by asking him to give a demonstration or talk. Parents then feel that they can contribute something to their children's education as well as to their general training. The whole idea of co-operation between home and school may be new and may have to be approached very gradually.

Parents need to realize that school work has real value in everyday life. No amount of book-learning on the children's part

will carry conviction: only useful practical work can be convincing. This is where village projects carried out by the older pupils can be so valuable.

If headmasters approve, an occasional open day for parents will do much to stimulate interest in what their children are doing. Such an event needs careful planning and control: it must not develop into an elaborate exhibition, which occupies too much time in preparation. Suggestions will be found in this book for some practical work which can well form part of a simple exhibition.

CHAPTER II

# Practical Work in Elementary Science

## THE VALUE OF PRACTICAL WORK

We can only teach well if we are convinced that the subject has some importance for the children. Some teachers look on the practical side of science as an extra, and rather a tiresome extra, because it usually requires more preparation than the purely oral lesson. If this is your attitude, you probably find that there is constantly some excuse in your mind for omitting the practical work, the most usual one being that the class is behind and must 'press on'. With what must they 'press on'? With learning more facts? We have seen in Chapter I that facts by themselves are not science. In a practical subject such as agriculture or domestic science, nobody thinks of failing to feed the animals or to cook the meal because the pupils must 'press on': the value of practical work in such subjects is obvious and is at once recognized. In science it is not necessary to spend so large a proportion of time on practical work, but once you understand its value you will not be tempted to omit it.

For the sake of simplicity we include here hints on the supply and use of 'specimens', that is, of any materials, living or non-living, which are used to illustrate lessons. When such material is properly used it gives opportunity for many observations and sometimes for experiments.

### (*a*) *Specimens for class use*

Children should see, handle and observe for themselves as much as possible. Nearly all science lessons require illustrative material of some kind. The teacher must first know where to find the material and then, by right use, get the greatest value from it.

*Obtaining specimens.* The golden rule is: 'Look ahead': consider before term begins what special materials will be needed, and see that you know where to find them. If seedlings or small plants in pots are needed for experiments, decide when to plant them. Above all, never start to prepare a science lesson just the evening beforehand, or you cannot hope to collect what you need.

It is always more difficult to get living material for lessons on animals, because one can seldom be quite sure when and where animals are to be found. But there is no excuse for failure to obtain material for the study of plants. Some suggestions on the provision of animals for study will be found in Chapter III (pages 30–33).

*Use of specimens in lessons.* Obtaining specimens takes time; if, then, you make poor use of them, your time will have been largely wasted. If rightly used, specimens should not only add interest to the lesson, they should also help the children to understand and to remember the subject. The use of specimens gives children practice in using their eyes and finding out things for themselves, while in some cases it enables the class to watch or perform an experiment.

The exact way in which you use your material will depend on the number of specimens and the size of the class, but in every case the most important point is to get the children to see with their own eyes and, if possible, to find out things for themselves. When studying plants it is often possible to give a specimen to each pupil; having done this, do not make the mistake of treating the specimens as you would a blackboard diagram. If you first tell the children to look for a particular feature, and then either point to it or ask them to find it on their own specimens, you are not training them to see for themselves. This kind of approach is sometimes necessary, but the more usual one should be this: ask a question that can *only* be answered by looking at the specimen. When one child has given the correct

answer, do all you can to make sure that the others have also used their eyes. If you make a habit of asking questions that any child can answer if he uses his eyes, the class will soon form the habit of looking at specimens with care, interest and increasing power to observe accurately. They will also learn not to pull their specimens to pieces at the beginning of the lesson.

Quite often you cannot give a specimen to every pupil, so you hand round one between every two or three children. They need to learn how to share fairly, or else one child who is interested will seize and keep the specimen, while the others may sit quietly by without trying to look at it. It is often useful to train the class to form themselves quickly into groups of four or five for the purpose of observation.

Frequently, especially when studying animals, the teacher can bring only one example, as for instance, a frog, a chameleon in a cage, or a butterfly in a jar. A beginner sometimes holds up quite a small specimen and talks about it as if all the class could see it clearly when only those in the front rows can do so. Some teachers carry the animal round the class so that all may have a closer view. This is sometimes useful, but it may result in a brief glance for everybody, with no time for anyone to observe properly. In upper Primary classes the children may be called up in groups to verify for themselves points mentioned during the lesson. This can be arranged while the class is making notes or drawings, so that time is not wasted and the teacher is left free to discuss the animal with each group in turn.

Perhaps the most valuable use for the single specimen is for *out-of-lesson observation.* Bring the animal to school before lessons begin, or better still, a day or two before the lesson. Encourage observation by asking, during the lesson, questions which can be answered by those who have watched the animal. As the children form the habit of observing, they will become eager to tell what they have seen. Sometimes you will direct their observations; for example, you may say: 'This little fish is going to be the subject of our lesson tomorrow; it will stay in the glass

jar, so you should all come to the lesson ready to answer these questions' (write them up):—

1. What parts of the fish are always moving?
2. How does the fish go forward?
3. How many fins has it got and where are they placed?

### (b) *The 'Nature corner' and its uses*

Most teachers of junior classes keep a Nature table in the classroom. An improvement of this idea is to put the table in a corner and use the walls for pictures, etc., making the whole into a 'Nature corner'. The table can be used for many purposes. Children in Year I can at first bring any objects which interest them; these are neatly arranged on the table for all to see, and may form the subject for a 'Morning News' talk. Next, a collection of particular objects such as seeds can be started. It is good to let the children take turns in looking after the neat, orderly arrangement. Try to avoid overcrowding, and to throw away dead or dying material regularly. A dirty, untidy table, with dead flowers or decaying fruits, is a most depressing sight.

With older classes collections, specimens, pictures, weather records and so on, will all find their place in the Nature corner, which should be used for material to illustrate the work in progress in the class.

### (c) *Making collections*

This activity can be valuable in three ways:

It brings children into direct contact with nature, and makes them familiar with many more specimens, for study in lesson hours.

It gives an opportunity for children to learn, in a general way, what is meant by classification.

It supplies useful material for class lessons.

In some countries many children, boys in particular, become keen collectors, especially between the ages of 7 and 11. In other countries this desire to collect seems much less marked,

and where this is the case it will be wise not to lay too much emphasis on collecting, for it is not an activity that can be forced.

Adopt some definite grouping for every collection, allowing the children who are put in charge to label the groups of objects. This is good training both in orderly arrangement and in the ability to recognize likenesses between objects. For instance, when the children in Year I bring flowers, you can decide to group them according to their colours; seeds might at first be arranged according to size, for grading in size is by no means easy for young children and is in itself a useful exercise. Later on the children will collect seeds and group them to show methods of seed dispersal. Thus a very simple kind of grouping is used at first, keeping the more formal classification for older children. There will always be examples which do not quite fit into any one of the groups, for nature seldom shows hard and fast boundaries.

In tropical countries most class collections must be temporary, for special methods and airtight boxes are needed to preserve dried plant or animal material. A few permanent exhibits such as stones, shells, or bones, can be kept for a time in the classroom and may afterwards be added to the school collection (see Chapter III, p. 26). Collecting insects is not recommended, because these soon suffer from mould and cockroaches. Also the children have no satisfactory means of killing insects. Any collecting which involves cruelty or destructiveness is to be avoided.

When a class has a collection neatly arranged, it is good to make a little exhibition of it. All that is needed is to ask some visitor, e.g. the headmaster or another class and their teacher, to 'come and see our exhibition'.

### (*d*) *Experiments*

An experiment is something we do in order to test the truth of an idea or a statement. Your success as a teacher of science will depend very largely on whether or not you use experiments

as a normal part of the teaching. The most careful explanations may leave children with a confused impression, whereas a few simple experiments make the point clear. It is important that children should realize that we can often test the truth of a statement by *doing* something ourselves. Experiments, in fact, emphasize that *doing* can be as important as learning from books, for while carrying out experiments we learn by doing.

In schools where activity methods are used, children bring forward problems that they wish to solve; they learn, with guidance from the teacher, to plan and carry out experiments that will help to solve the problem; they consult books; and they tell other members of the class what they have found out. Such methods encourage the scientific attitude, but the teachers need to have had special training, reference books are necessary, and the children's background should be one which encourages independent thought and action.

In this book it is assumed that experiments will be used to illustrate a set course of work, and in Part II there are numerous suggestions for simple experiments, which can be done chiefly with everyday articles or home-made equipment.

Large classes and shortage of materials may make it impossible for the children to carry out experiments individually; where this is the case, the teacher must do the experiment while the children watch, and assist wherever possible.

The way in which an experiment is introduced is important; so is the accompanying discussion and the conclusions drawn from it. The following general rules should be observed:—

1. Always try an experiment yourself before doing it in the class for the first time.

2. Make certain before the lesson that you have everything you will need, e.g. even such small articles as a box of matches or pins.

3. Lead up to the experiment in such a way that the class know why the experiment is being done, but *avoid mentioning the results that you expect to get*, for if you do this the children

become mere spectators at an entertainment. Instead, *ask the class to observe closely and be prepared to report what they see*; in this way you train them to watch carefully and to think about what they see.

4. With large classes, where all cannot see clearly, select observers who report to the class what takes place. It is naturally more satisfactory if the whole class can be grouped round the teacher as he carries out the experiment.

5. Discuss the result so that the children are clear as to:—

(i) what we did,
(ii) what happened,
(iii) what the experiment showed.

6. Take every possible opportunity of letting children do things themselves.

*Controlled experiments.* There is another very important rule: in any experiment, try to arrange a *control.* This means that you must try to ensure, and let the children make sure, that the results obtained are really due to certain causes and not to others. (The history of science shows how easy it is to draw wrong conclusions from experiments done without controls.) A good teacher will always try to find suitable controls for his experiments, and many examples are given in this book.

Suppose you wish to show what happens when a candle burns in a closed jar of air. Then you should have a similar jar with an unlighted candle in it, and whatever you do to the first jar (except for the lighting of the candle) you should also do to the second. Your pupils will then know that any differences they observe are due to the burning of the candle. Again, if the children are to find out that a plant cannot live without water, they must use two similar plants in exactly the same conditions, except that one is given water and the other is not: the results can then lead to a definite conclusion about the effect of water. Most of the simple experiments to be done in the Primary School can be controlled in easy ways like these. There are, however,

many other ways of setting up controls in experimental work, and some of them are very difficult, but the principle is always the same: to try to make sure that a correct conclusion can be drawn from the result.

Even young children can be quick to see a weakness in an experiment and the conclusions drawn from it; but they may fail to understand what you are doing unless you keep your controls simple. By the proper use of controls you are teaching, indirectly, a most important part of scientific method.

(*e*) *Walks and excursions*

Outdoor observations need careful planning. Sometimes classes wander aimlessly for a whole lesson, and the time is largely wasted. If you take a class out to see a particular animal or plant, be sure that you know where to find it. Before a longer walk or excursion, explain the aim of the trip: discuss the visit with the class, so that they know something about what they will see and can take an intelligent interest. When preparing an excursion to some place of interest, make all arrangements well beforehand. Obtain your headmaster's consent; get into touch with those in charge of the place that you wish to visit, and try to get their interest and co-operation in addition to their consent. After the excursion spend a lesson period in discussion of what was seen, perhaps making some form of record.

*Record-making in connexion with practical work*

We have seen in Chapter I that making records should be part of training in observation. We may now ask: what form should records take in the Primary School?—what degree of accuracy can we expect of young children?

The youngest children report their observations mainly in speech. As they learn to write, they may help the teacher to decide on a few sentences, which they copy from the blackboard. They can only record their own observations in writing when they have fair mastery of their written language: hence for

the first four years children's records will be mainly drawings. There will also be some class charts kept by the children.

*Children's drawings*

Why do we ask children to draw an animal or a plant? Is it an easy way of filling in time in class? Or is it just a pleasant occupation for the children? Or has it real value as part of their science training?

Drawing is valuable in the science lesson because:—

1. It is an enjoyable form of expression for young children.
2. It trains the power of observation.
3. It aids memory, since the effort of drawing focuses attention on the object.
4. It is a concrete method of recording facts, and one which is usually much more valuable to young children than the written word.

A teacher should know what kind of drawings to expect from children of any age group in the Primary School. In general, drawings by children up to 8 or 9 years old are a form of free expression; accuracy and detailed observation are not to be expected. You have to get right away from adult types of drawing if you are to give sympathetic help and advice to a child of this age. What matters is that he makes the attempt to express what he has seen or learnt: the method that he adopts is not important. As an example of the features commonly met with in drawings by young children, take the picture of a cat in Figure 2. There are four stick-like legs placed at almost regular intervals along the body; the whiskers and claws are far too long. A sense of proportion is not to be expected from children of this age, and it is common for them to draw too large the features which interest them or which they

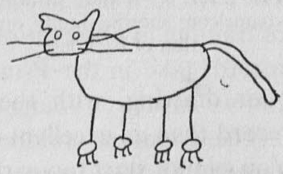

FIGURE 2.—Drawing of a cat by a six-year old child

think important. This child has expressed very well some of what he knows about cats, and so his drawing is to be commended.

Very gradually children develop the ability to look at an object and observe the shape, colour, proportion and relationship of its parts; now their drawings aim at making a likeness of the particular object which they observe. Whenever possible let them draw from life instead of copying blackboard sketches. If there is only one specimen, which is either in a cage or pinned on the blackboard, those who cannot see the details can come up in groups for close observation. The teacher walks round, giving helpful criticism. Always avoid stating directly what is wrong; indicate instead where the mistake lies and ask the child to look again. For example, if a child has made a drawing of a chameleon like that in Figure 3, you say: 'Are you sure the legs are right? Look at them again.' The child has failed to notice the unusual forward bend of the back legs. In this way children discover their own mistakes and learn to observe more accurately.

Do not allow the practice of ruling 'frames' round each drawing. This is a great waste of time and also of paper, though many children enjoy doing it, probably because no mental effort is needed.

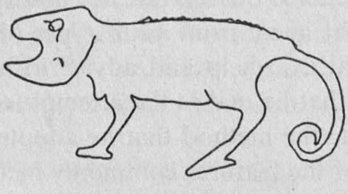

FIGURE 3.—Child's drawing of a chameleon: showing faulty observation of back legs

The importance of *drawings* as a method of recording facts depends largely on whether they *are named and labelled.* A rather poor drawing, with the parts correctly labelled, is a better record than an excellent drawing with no words of explanation. You cannot start too early to insist on a title for every drawing; later you will show the children how to label drawings. The rules are:—

words must be placed well away from the drawing;
pointer-lines run from the first word to the *exact* part of the drawing referred to;
pointer-lines and words should, when possible, be horizontal, though one should not lay too much emphasis on this in the Primary School, or the children will spend far too long in ruling horizontal lines.

Well-labelled drawings are often better records than notes, e.g. when studying the growth of seedlings or comparing the growth of plants under different conditions.

CHAPTER III

# Primary School Science Materials

*The need for the tools*

Any practical subject requires tools and materials, and, recognizing this, school authorities make some provision for these necessities. In science, then, tools and materials are necessary, but since elementary science is rather a new subject in Primary Schools, the need for adequate equipment has often been disregarded. It is common to find schools well equipped for teaching woodwork or domestic science, but without any equipment for practical science-teaching. The equipment needed for work suggested in this book is very simple: much of it can either be collected at home or made by teachers and pupils. There are, however, a few items which must be bought, and there ought to be a small grant or allowance for this, as in the case of other practical subjects.

A list of materials required for the practical work outlined in Part II is found in the appendix on page 225. The list is divided into 'equipment that can be collected' and 'equipment that must be bought'. This is a rough and ready classification, for things that can be collected in one place may have to be bought in another, while some teachers can make what others would have to buy. Every teacher is urged to use his ingenuity in order to make the fullest use of local materials. The aim in Primary School science should be to manage with the simplest possible equipment, making use wherever possible of familiar objects: in this way science becomes a means of understanding more about our surroundings and everyday life. So if you have not got and cannot obtain something which the book recommends, then look round and try to think of a substitute; in fact, try out your own experiments.

*Storage of equipment*

Proper arrangements for storage, checking and supervision of equipment are extremely important. Even things which are in common use in the home, such as tins and string, have a strange way of disappearing; and it would clearly be most unwise to allow free access to materials which have to be bought out of a small grant. Hence part of the essential equipment is a *School Science Cupboard*, which is kept locked when not in use by the teacher. Here are stored all science materials, except small articles of relatively little value such as tins and jars. One teacher is in charge and he checks the list of contents at regular intervals. Teachers taking out materials sign in a book and sign again when the things are returned. Breakages are reported to the teacher in charge. All articles must be clean when returned.

It is a good idea for each class teacher to hand in at the beginning of term a list of articles that he expects to need. The teacher in charge looks through the lists and sees if any adjustments are necessary so that two classes do not require the same thing at the same time. Such lists are also a useful way of ensuring that teachers *do* review the practical work for the term right at the beginning.

Every teacher should keep in his class a few tins, glass jars, pieces of mosquito netting and string. Wherever possible each class should have its own small cage for any small living animals that are brought.

*Notes on some items of equipment*

*Glass jars.* These are used for many purposes because we can see what takes place inside them. Although jam is now usually provided in tins, there is still a variety of foods sold in clear glass jars. Each school should build up a good supply of these; they are essential for science work. The most useful are those with straight sides and wide mouths.

*Bottles and corks.* For a few important experiments a glass bottle

must be fitted with a cork through which a tube passes. To make a neat hole of a given size through a cork, a cork borer is necessary. When fitting a cork into a bottle, first roll the cork gently under your foot in order to soften it. The borer has several tubes of different diameters, so that you can select one the right size for your tubing. Hold the cork steady on the table. Press the borer firmly downwards, taking care to keep it upright all the time, and constantly turning it forwards and backwards. (It is a good idea to bore half-way through the cork and then complete the hole by boring from the other end.) A drop of oil helps the borer to turn more easily.

*Glass tubing*. Soda-glass tubing should be ordered, because it is the cheapest and the softest type. To cut the tubing, make a scratch with a triangular file; then the tube breaks easily and neatly at that point. After breaking, soften the ends in a flame so that there are no sharp edges. Soda glass can be softened in a

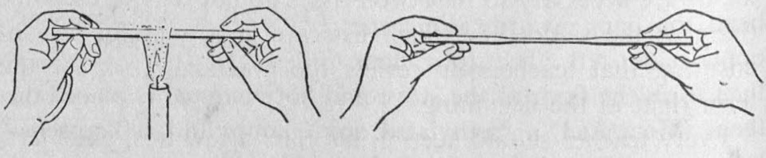

FIGURE 4.—Softening soda-glass tubing (in a candle flame) in order to draw it out

candle flame. If you wish to obtain a pointed end to the tube, roll a short length of tubing between finger and thumb of both hands, holding it in a flame as in Figure 4. When the glass is soft, gently draw the two ends outwards; take it from the flame, make a scratch with the file in the middle of the thin part, then break, and round off the sharp edges in the flame.

To bend glass tubing, soften it in the flame, being careful to keep it revolving, so that all sides are softened to the same extent. Then allow one end to drop gently until the required angle is obtained. To be successful this operation needs practice,

but you can avoid having to bend glass tubing, if you join two straight pieces with a short length of stout rubber-tubing.

Narrow bamboo tubes can be used in place of glass tubing except where transparency is necessary.

*Source of heat for experiments.* It is essential to have some means of heating water and other substances in the classroom. A simple *charcoal stove* is recommended as being the cheapest and best source of heat for the majority of schools. It can easily be made from a tin. Figure 5 shows how to convert a large cocoa tin into a stove. (Any fairly big tin will do.) Mark four 'windows' in the tin near the bottom; pierce one or two holes in each; then cut along two sides of each window (not the top) and bend the flaps inwards along the upper side AB. The four flaps then form the floor of the stove and hot charcoal is placed on them. Meta fuel, a methylated spirit lamp and a kerosene-burning stove are all useful, but considerably more expensive than the charcoal stove.

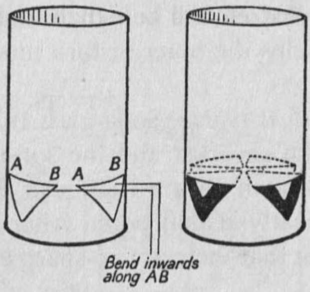

FIGURE 5.—A charcoal stove made from a tin

*Provision of living material.* In most tropical countries there is no shortage of living material around the school and in its own grounds. But even when full use is made of the material naturally available, much more will be needed, and the children should have opportunities for growing plants and for watching and caring for living animals. Detailed suggestions for school gardens do not fall within the scope of this book, but it is assumed that in some, or all, of the classes the children will cultivate their own small plots, and will learn in an elementary way about good methods of gardening and farming. In addition,

classes might take it in turn to tend plants that add beauty to the school, e.g. verandah plants in pots or hanging baskets, small flower beds and quick-growing climbers.

The provision of living animals for study is less easy. Whenever the school is closed, as at week-ends, there is likely to be difficulty about feeding and watering the animals. It cannot be too strongly emphasized that captive animals must be properly cared for; it is better not to keep animals at all than to keep them under conditions which bring misery and starvation. The children will be delighted to have an animal, a chameleon for

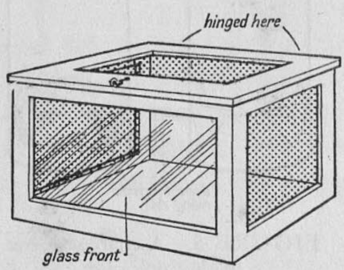


FIGURE 6.—A small cage: a wooden box with hinged lid at the top, glass front, and gauze sides and top

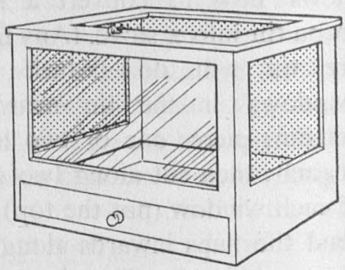

FIGURE 7.—An improved cage: like that in Fig. 6, but the bottom is a drawer

example, but *if the animal takes no food it must be set free* before it begins to show signs of starvation. If necessary alter the order of the syllabus; take a lesson on the animal at once and then replace it in surroundings where it can find its own food. Snakes and other reptiles can go for long periods without taking food, but every animal must have water. It follows that, as a general rule, animals, including insects, will be kept in school for short periods rather than permanently.

*Cages for small animals* can be made from wooden boxes, and can be of various types and sizes. Figure 6 shows a simple box type; a hinged lid has been fitted; large windows are cut in the lid, front and sides; glass is fitted in the front window,

while the others are fitted with wire mosquito-gauze. A cage which has no glass side is not much use for observation; every school ought to have at least one such cage, and if every class can have one, so much the better.

The cage shown in Figure 7 is an improved type because it is easy to clean; the shallow drawer at the bottom can be removed for cleaning without opening the cage. If possible, line the drawer with metal.

A small tin can be used as a feeding-trough, if the cut sides are rolled inwards to avoid sharp edges (Figure 8). If this hangs by wire hooks, it can be removed without reaching right down into the cage. Some animals, mice for example, will drink water from a drinking tube. Make this from an ink bottle fitted with a cork through which passes a short glass tube which has been drawn out to a short point. Hold the bottle upright under water and insert the cork and tube under water; you can now hang the bottle, tube downwards (Figure 9), in the cage, and the animals suck water as they need it, and scarcely any is lost by evaporation.

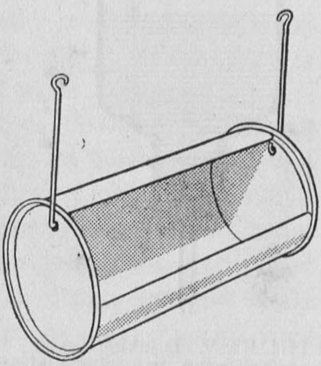

FIGURE 8.—A small feeding-trough for use in a cage. (The tin has been cut down its side and the rough edges have been turned inwards)

*Keeping caterpillars* is simple if you know their food-plant and can obtain a regular supply of it. Fresh leaves are essential, as caterpillars will refuse any that are slighly faded. Figure 10 shows a good way of keeping the leaves fresh. A shoot of the food-plant is put inside a lamp-chimney, and then both shoot and chimney are pushed into very damp soil in a flower-pot. Remove the shoot and put a fresh one in as often as necessary.

Caterpillars may be easily reared in one of the insect cages, shoots of the food-plant being placed in a small jar of water. When caterpillars are ready to pupate they stop feeding and begin to crawl about quite rapidly. Many moth caterpillars pupate in the soil; these need a layer of soil 2 or 3 inches deep in the bottom of the cage. Keep the soil moist, but not too wet, until the insect emerges.

It is important that children should follow a complete life

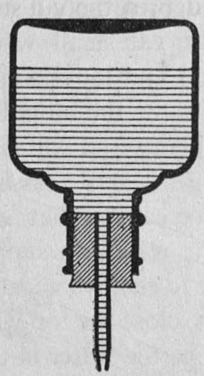

FIGURE 9.—Drinking vessel for mice: made from an ink bottle, a cork, and a piece of glass tubing

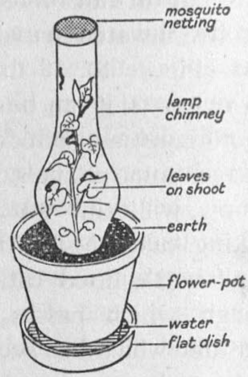


FIGURE 10.—This shows how to keep caterpillars with fresh food

history. Get help from an authority, and find out about a butterfly or moth which is plentiful in your district and which is easy to rear. Try to find one that has a short life history, i.e. that does not remain in the pupa stage for too long.

*Keeping tadpoles and other freshwater animals.* As a glass tank is expensive and difficult to get, most schools will have to do without a 'balanced' aquarium in which plants and animals live healthily together. But various freshwater animals can be kept for short periods in glass jars or open pans. Bowls and pans have the advantage of a large water surface; their drawbacks are that they make observation less easy and that those with white

enamel surfaces reflect too much light. Glass jars make observation easy, but the very small water surface means that the water must be changed more often. For rearing tadpoles to the adult stage a fairly large bowl is necessary, and remember to put in a stone which projects out of the water, when the tadpoles are changing into little frogs. Put only a very few animals in each vessel: for instance, two tadpoles and one small water snail will be enough for one glass jar (1 lb. size). Include some healthy green water-weed in each vessel and preferably also a snail, for this acts as a scavenger. Tadpoles eat small water plants, and, if the water is taken from a pond and looks somewhat thick and green, there will be food in it for the tadpoles. They will also nibble at the leaves of water plants and will take small quantities of cereal food such as rice or 'gari' (cassava 'flour'). The disadvantage of feeding on cereal is that any which is uneaten rots quickly and fouls the water, so supply only a few grains at a time. (Use a glass tube to remove uneaten grains: put the end of the tube over the grain, close the top with a finger and then lift out the tube.) To change the water in the jars, tie mosquito-netting tightly over the tops, pour off most of the water and quickly put in a fresh supply of *pond*-water. This procedure is not necessary, of course, when keeping small insects such as mosquito larvae.

*Making a rain-gauge.* For junior classes any large tin can be used to measure a fairly heavy fall of rain. The depth of water is measured directly by putting in a wooden scale marked in inches and quarters. (Make sure that the scale starts at the end, not about $\frac{1}{4}$-inch away as it does on most rulers.) If possible this simple rain-gauge should be painted to prevent rusting.

Senior classes should measure rainfall more accurately—to the nearest one-tenth of an inch. A similar tin is needed: it should be at least 6 inches high and not less than 3 inches in diameter, preferably wider. Make, or get a tinsmith to make for

you, a tin funnel which fits over the tin and is of the same diameter. Now find a narrow, flat-sided bottle such as an ordinary medicine-bottle for use as a measuring-jar. Stick a strip of paper down one side of the bottle. Now pour water into the tin to a depth of exactly 1 inch, and then, using a funnel, very carefully pour all this water into the bottle. Mark on the paper the level of the top of the water and of the inside of the bottom of the bottle. Divide the distance between the two marks

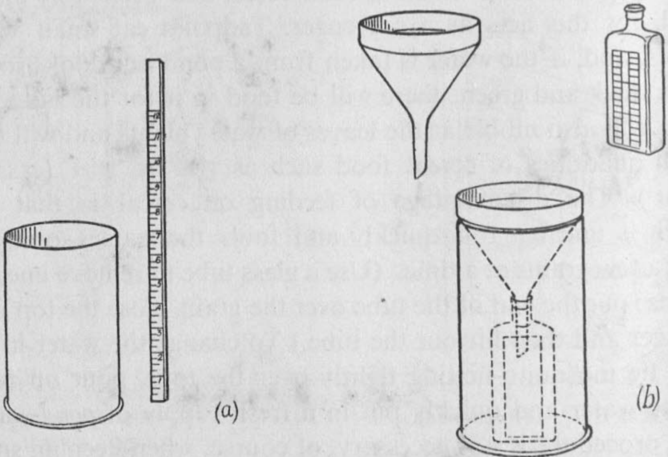


FIGURE 11.—A rain-gauge

(*a*) Tin and measuring rod
(*b*) Tin, funnel and measuring bottle

into ten equal parts: each part will represent a rainfall of one-tenth of an inch. (See Figure 11.)

When the gauge is in use it is best to keep the bottle inside the tin under the funnel. A rainfall of 1 inch or less can then be measured by direct reading from the scale and without any pouring of water from the tin, thus avoiding the risk of loss of water. If more than 1 inch of rain falls during a 24-hour period, the bottle will be filled above the 1-inch mark and may overflow into the tin. To measure the rainfall, enough water must be poured out of the bottle into the tin to lower the level of water

inside the bottle to the 1-inch mark. Then the bottle must be emptied, and the rest of the rain-water measured by pouring it from the tin into the bottle (using the funnel to avoid loss). During very heavy rain the fall may amount to several inches, i.e. you may have to fill the bottle to the mark several times: do this carefully and remember to count the number of inches you empty away.

*Note:* the straight-sided part of the bottle must hold the depth

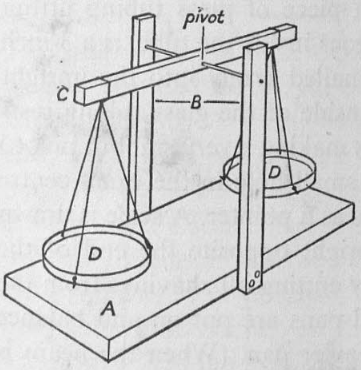


FIGURE 12.—Home-made scales

A. Base: about 18 in. × 8 in. × 1 in.
B. Uprights: about 12 in. high
C. Beam: about 15 in. long
D. Pans: about 6 in. diameter

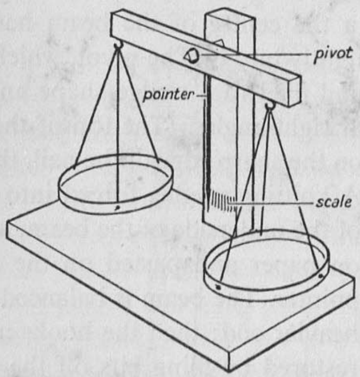


FIGURE 13.—Another home-made balance

Wooden base: about 12 in. × 6 in. × 1 in.
Wooden upright: about 12 in. × 2 in. × $\frac{3}{4}$ in.
Wooden beam: 9 in. × $1\frac{1}{2}$ in. × $\frac{3}{4}$ in.
Pans: tin lids, about 4 in. diameter, hung from hooks by strong thread

of one inch of water from the tin; for good results the tin (and funnel) must not be less than 3 inches across; nor must the height be less than 6 inches, otherwise splashing is likely to spoil the results. In other ways the sizes of tin and bottle do not matter.

*Home-made weighing instruments.* The simple balance or pair of scales shown in Figure 12, where the sizes of the parts are given, can easily be made. The base, uprights and beam are of wood. The beam has a round, smooth hole bored through the

middle and is balanced on a strong knitting-needle. The pans are made of either lids of tins or three-ply wood, and are hung by stout thread. The distances from the pivot (the point of balance, i.e. the hole through which the knitting-needle passes) to the points where the pans hang are exactly equal. The beam is made to balance by cutting off small bits from its heavier end.

Teachers who are good at handwork can make a much more accurate balance like the one in Figure 13. In this case the pans can swing more freely, and they are hung from hooks. The hole in the centre of the beam has a piece of glass tubing fitting tightly into it. The pivot, which goes inside the tube, is a 3-inch nail filed to a wedge shape and nailed firmly into the upright at right-angles. (The top of the inside of the glass tubing rests on the sharp edge of the nail, thus making a very smooth pivot.) A knitting-needle, forced into a small hole in the exact centre of the underside of the beam, acts as a pointer. A scale is drawn on paper and pasted on the upright opposite the end of the pointer. The beam is balanced by cutting off shavings from the heavier end; then the hooks and pans are put on and balance restored by filing bits off the heavier pan. (When the beam is balanced the pointer swings an equal number of divisions to each side of the centre of the scale.)

Objects to be weighed are always put on the left-hand pan of a balance. Weights are then added to the right-hand side until the pointer shows that they are balancing the object.

*Weights for scales.* Remember that your balance is not accurate: it would not do for a shopkeeper, but it is quite good enough for children to use at school. (All their work must be careful, but at their age it cannot be highly accurate.) Your weights need not be very accurate therefore. If you cannot buy a new set or find an old set, you must try to make some models. You can do this by taking a small, wooden beam, about an inch thick and three inches wide, and cutting off lengths. If you mark a 16-inch length '1 lb.', then an 8-inch piece will be a '$\frac{1}{2}$ lb.' and

so on. However, you can do better than this, if you can get somebody to weigh your piece of wood (which must be planed by a carpenter, so that it is the same width and thickness all along its length). Knowing its weight you can calculate what length is needed to weigh 1 lb., 1 oz., etc. You can do better still if you are able to test each of your 'weights' against real ones on a good pair of scales.

It is convenient to have the following weights: 2 lb., 1 lb., $\frac{1}{2}$ lb., $\frac{1}{4}$ lb.; 2 oz., 1 oz., $\frac{1}{2}$ oz., $\frac{1}{4}$ oz.

*The spring-balance.* When using a pair of scales or a beam-balance you find the weight of an object by *balancing* it against known weights. A spring-balance seems to work quite differently because no weights are needed: we hang the object on a hook (or on a pan hanging from a hook) and read the weight directly from a scale. The weight is given by the amount of the pull on a spring inside the balance. But *the scale was made by using 'weights'*. For example, a 1-lb. weight was hung from the hook; the little pointer on the spring came to rest at a point which was then marked '1 lb.'; this process was then repeated with other weights. Thus, in using a spring-balance, we are *indirectly balancing* the object against other objects whose weight is known. This is not easy to explain clearly to children, but if they help to make a spring-balance they will readily understand the idea.

*A home-made spring-balance.* Instead of a spring use a strip of rubber cut from an old inner tube of a bicycle tyre. Tie one end to a hook or nail in a wooden frame, as shown in Figure 14. To the other end tie a hook, or a pan made from a tin lid. A long needle or a piece of thin wire is pushed through the rubber strip near its lower end to act as a pointer. A strip of paper is pasted to the upright ready for the drawing of the scale.

The base of the stand should be at least 8 inches square; the upright at least 12 inches long. You will have to experiment

beforehand to find out what height must be left below the bottom of the upright to allow for the strings of the scale-pan and the stretching of the rubber. (12 inches will probably be about right to start with—see Figure 14.)

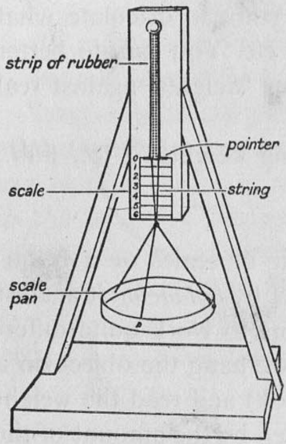


FIGURE 14.—A home-made spring-balance

Base: at least 8 × 8 in. and 1 in. thick
Upright: 2 × 1 in., at least 12 in. long; suitable height of lower end above the base to be determined by experiment
Scale-pan: about 4 in. diameter
Pointer: about $1\frac{1}{2}$ in. long

Now you must make the scale. Put a line on the paper, along the pointer, when there is nothing on the pan, and mark it 0. Put a 1-oz. weight on the pan, mark the new position of the pointer; repeat with a 2-oz. weight, and so on. Write in the weights represented by each line. If your divisions turn out to be large, you can divide them into halves or quarters in order to get smaller weights recorded on the scale. (In this description it is assumed that a 1-oz. weight will stretch the length of rubber by at least one quarter of an inch; but everything will depend upon the piece of rubber you choose: small weights will stretch a thin, narrow strip; with a good piece of thick rubber, you may be able to weigh in pounds.)

Points to note: (i) care must be taken to arrange that the rubber cannot be stretched far enough to get spoiled or broken; (ii) the rubber must be replaced when it begins to perish (i.e. to lose its powers of stretching and returning to its usual length)—the class should assist in making the new scale each time; (iii) the stand will always be useful: senior boys may be able to help in making several of them.

*How to filter liquids*. You will need a small funnel, between

2 and 3 inches deep. Blotting-paper is used as the filter: cut a circle 4 inches in diameter; fold it in half and then in half again, as in Figures 15*a* and *b*. Open out the paper to form a

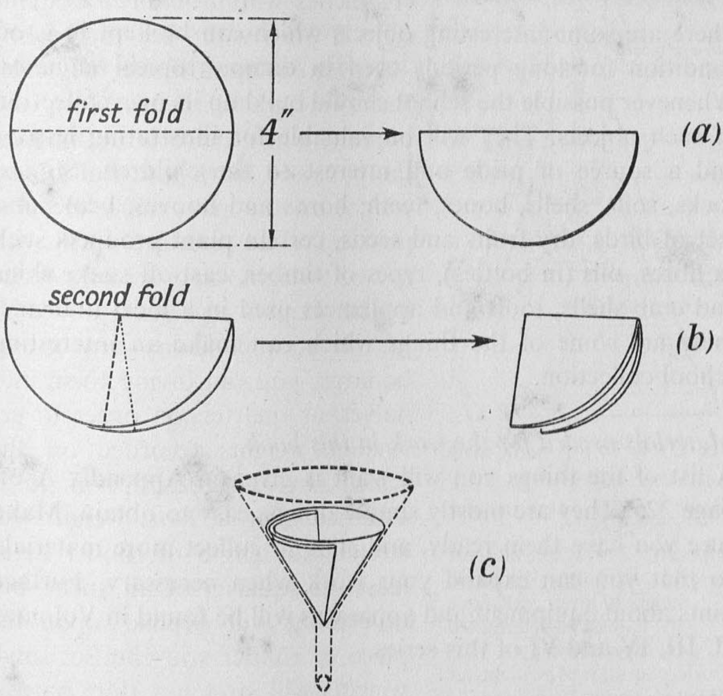


FIGURE 15.—How to fold a filter-paper (a circle of blotting-paper)

cone: there will be one thickness of paper on one side of the cone and three thicknesses on the other side (see Figure 15*c*). Now fit the cone into the funnel; if it does not fit exactly, the size of the cone can be adjusted by slightly altering the angle of the second fold as at the thinner dotted line in Figure 15*b*.

*To make lime water*. Use fresh lime which is sold for making 'whitewash'; stir it in water and then filter it; the clear liquid which comes through is lime water. As it quickly takes up car-

bon dioxide from the air it will soon become cloudy, so make a fresh supply whenever it is required.

*A school science collection*

There are some interesting objects which can be kept in good condition for long periods even in damp, tropical climates. Whenever possible the school should build up its own collection of such objects. They will be valuable for illustrating lessons and a source of pride and interest to the children. Stones, rocks, soils, shells, bones, teeth, horns and hooves, beaks and feet of birds, dry fruits and seeds, certain plant products such as fibres, oils (in bottles), types of timber, cast-off snake-skins and crab-shells, tools and appliances used in a local industry: these are some of the things which can make an interesting school collection.

*Materials needed for the work in this book*

A list of the things you will want is given in Appendix A on page 225. They are mostly simple things, easy to obtain. Make sure you have them ready, and start to collect more materials so that you can expand your work when necessary. Further hints about equipment and apparatus will be found in Volumes II, III, IV and VI of this series.

*Books*

Reading is of great value to anybody. It gives recreation, brings new ideas, shows you how other people think and work, and widens your outlook; it can also increase your knowledge of language and of what you are trying to teach, and it can improve your teaching methods. In Appendix B, on p. 228, you will find a list of books. It is a selection from hundreds of books, many of which may be just as good as those suggested. The first part of the list consists of the sort of books which should be found in every Primary School library or reading corner, and read by pupils and teachers. The second and

shorter part of the list is for teachers only: to help you to get a better grasp of how to teach science.

The kinds of books in the list are needed in every country. They are best when written in the native language of the people, so it is to be hoped that, before long, good teachers all over the world will be able to write such books for their own countries.

the one part of the [illegible] for [illegible] to [illegible]
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The kinds of books in the future needed in every country.
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# PART II

# Outline of the Grouping of Subject Matter for a Six-Year Primary Course in General Science

## Year I

| LIVING THINGS | EARTH AND UNIVERSE | MATTER AND ENERGY |
|---|---|---|
| *Plants* may be large (trees), or small. They have stems, roots, leaves and flowers. They are alive and need water and food. | *Weather:* general observations during informal talks. In connexion with these give very simple lessons on *air*, *water*, *clouds* and *rain*. | |
| The plants' *seeds* are *scattered* in different ways. | *The sun*—how it seems to move. How the sun helps us. | |
| *Animals* need water and food. Animals often make homes and care for their young. How we should care for animals. | *Shadows*—what makes them and how they change during the day. | |
| | *The moon*—it seems to change in shape, but is always the same moon. | |

## Year II

| LIVING THINGS | EARTH AND UNIVERSE | MATTER AND ENERGY |
|---|---|---|
| *Fruits* grow from flowers. Fruits contain seeds.<br>*Seeds* contain food and a tiny plant.<br>We can grow plants from seeds and sometimes from stem *cuttings* or *underground food stores.*<br><br>Men and animals use various parts of *plants for their food.*<br><br>*Animal life histories* to show how animals change as they grow up and how they move about in different ways in search of their food. | *Weather observations.*<br><br>*The earth* is round.<br>*Day and night* depend on the movement of the earth which turns round once in 24 hours. The earth is made up of land and water and is surrounded by air.<br><br>*Land* is made up of rocks and soil.<br>*Soil* is made from rocks and plant and animal remains; it contains air. Plants need good soil for growth.<br><br>*The moon* appears to change in size and shape during each successive 4 weeks. | |

## Year III

| LIVING THINGS | EARTH AND UNIVERSE | MATTER AND ENERGY |
|---|---|---|
| All living things need water and air.<br>*Plants and water*—water taken in by the roots; passes up stems to leaves. Plants give off water from the leaves in the form of vapour.<br><br>*Different kinds of leaves.*<br><br>*Roots grow downwards.*<br>*Stems grow upwards.*<br><br>*Animals* usually *drink water* through their mouths. They go in search of water.<br><br>*Protection.* How animals and some plants are protected from their enemies.<br><br>General rules for clean and desirable *health habits.*<br><br>Life histories of *Cockroach, housefly* and *mosquito* (some insects that we do not want about our homes). | *Movements of the earth,* causing day and night, and the apparent movements of sun, moon and stars. The earth's journey round the sun in one *year.*<br><br>*Air* occupies space. Air is needed for *burning.* | |

## Year IV

| LIVING THINGS | EARTH AND UNIVERSE | MATTER AND ENERGY |
|---|---|---|
| 1 (*a*) *'A' Scheme.* *Classification.* Animals and plants chosen to represent the main groups.<br><br>1 (*b*) *'B' Scheme.* *Local crop plants and farm animals* — their life histories, diseases and enemies.<br><br>2. *All classes.* *Parts of the flower* and their uses. *Pollination.* *Decay.* *Soil fertility.* *Water supply.* *Diseases* connected with unclean water. Infectious diseases *Simple first aid.* | *Weight.* Simple home-made scales and how to use them. Very simple idea of density.<br><br>*Air* presses in all directions. Hot and cool air. *Winds* and how they are caused.<br><br>*Water*—how it circulates in nature and how it can change so that it is *solid*, *liquid* or *gas*.<br><br>*The thermometer*—its uses and how to read it.<br><br>*The cooling effect of evaporation.* | *Tools and machines*—devices by which work is made easier: *wheels*, *axles* and *levers*. *Gear wheels*—some of their uses in very simple machines. *Springs* used to do work.<br><br>Man can use *wind power* and *water power* to make his machines work.<br><br>*Engines* can be driven by coal, petrol, oil or electricity. |

## Year V

| LIVING THINGS | EARTH AND UNIVERSE | MATTER AND ENERGY |
|---|---|---|
| *How animals and plants live.* Very simple outline of the chief systems of the human body and how they work. How a green plant grows and respires. | *The earth. Tilt of the earth's axis*—effect of this on length of day and night throughout the year; how it causes winter and summer in places far from the equator. | *Heat.* Sources of heat. |
| | | *Breathing, burning* and *rusting* all use oxygen. Breathing and burning produce carbon dioxide and water. |
| *Animal parasites* and diseases caused by them. | *The earth's crust*—what it is made of, how it is worn away and how new rocks are formed (very brief outline). | *Air* is a mixture of gases. |
| *Health teaching and care of the body.* To be taken in connexion with the account of the human body (as above). | *Minerals* from the earth's crust. | *Fire:* its dangers and uses. How to put out fire. |
| | *Coal and fuel oils* from the earth's crust. | *Expansion* due to heating. The thermometer. |
| | *Soil* and how it is formed. | *Good and poor conductors* of heat. |
| | *Soil erosion*—its dangers and how to prevent excessive erosion. | |

## Year VI

| LIVING THINGS | EARTH AND UNIVERSE | MATTER AND ENERGY |
|---|---|---|
| *Reproduction* in plants and animals. | *The earth* as part of the *solar system.* | *Machines:* levers, screws, gears. |
| *Nutrition and diet.* | *Phases of the moon* and how they are caused. *Eclipses.* | *Friction*—oiling and care of simple machines. |
| *Social animals.* | *Water* and *water pressure*, reservoirs, pumps and water power.* | *Light:* sources of light. Reflections. Bending light. Magnifying-glass and spectacles. *Colours. The rainbow.* |
| *Science in relation to local community.* If possible carry out some project in the village; some of the following subjects may be suitable for teaching in connexion with the project. | *Thunderstorms.* | *Sound:* vibrations. Sound travels and can be reflected. Echoes. Musical instruments. |
| *Diseases and pests* and methods of control. | *Rainbows* (see Light under Matter and Energy, Year VI). | |
| *Plants and their uses to man.* | | |
| The *Public Health Services.* | | |

* If possible do this as part of the project (see Living Things, Sixth Year).

## THE SYLLABUS

Remember that the table of subject matter, and its grouping, is given to serve as a *guide*. There are many things to teach and many ways of teaching them: this book shows you some suitable topics and some good methods of teaching them.

What you teach will depend upon:—

(*a*) The school authorities, i.e. the government and the educational system of your country. You may have to follow a special syllabus, but you will find that it contains much of the subject matter given here: so you will find help in teaching it. The practice you get will also help you to teach any different or extra topics.

(*b*) The environment of the school, i.e. the sort of country and climate you live in. You should choose your topics according to your surroundings, the season of the year, the weather, and so on. In other words, always try to start with things familiar to the children.

(*c*) Your pupils' home background, i.e. the kind of houses, furniture, gardens, farms, etc., where they live. As far as possible, choose your teaching material from things the children know.

(*d*) The school time-table, i.e. the amount of time you can spend on the teaching of science. Do not try to do too much, nor to go too far, with any topic, in the time you have. You have to be thorough, but should not spend too long on one topic. Try to keep the children interested all the time, and to avoid too much repetition and revision.

(*e*) The ability and ages of your pupils. When children are very young, they need short and simple lessons. As they grow older, they can go on rather longer, and can reach a higher level of reasoning. Again, some children learn more quickly than others. The above syllabus, followed in this book, is meant to indicate the *minimum* subject matter, in science, for children at Primary Schools.

This means that *you* have to think out what will be best for *your* pupils. Everything depends on *your* circumstances. For

example, in the above syllabus the column headed 'Matter and Energy' is left blank for the first three years. However, if your school is in a town where there is industry and transport, you may be able to give simple lessons connected with machines and engines, at quite an early stage. (These lessons would be likely to arise from children's questions, asked because of their interests and surroundings.) On the other hand, a lesson concerned with a railway engine might be a waste of time if your town is a long way from a railway.

Always try to give an answer, clearly and simply, to a child's question. In this way you will find many chances for incidental teaching—often outside school hours—and this can be quite as important as the set lessons. Thus you may find that you teach some of the topics earlier than is suggested in the above syllabus. There may be time and opportunity to include other topics as well. Some examples are given in the list below. If you do teach about them, always make the lesson simple enough for *your* class to understand and remember. You can always take the subject further, if necessary, as the children get older. Such books as those mentioned in Appendix B will help you to decide on the best lines of approach for the lessons.

## EXAMPLES OF ADDITIONAL TOPICS

(These are for lessons, not lectures. Wherever possible, they should be the basis of problems to be solved. A good teacher will make use of pupils' questions, and from them get the clear statement of a problem and of what is already known. By careful questioning, he will go on to help the class to decide what else may be found out by observation and experiment. Ways of finding out will be discussed and tried. Lastly, it will be seen whether the results lead to definite conclusions and a solution to the problem.)

More about the weather

- Wind; its effects; its force.
- Storms.
- Drought and flood.
- Water in the air.
- Clouds, rain, mist, dew.
- Rainbows.

| | |
|---|---|
| **Plants, animals, and the seasons** | |
| Protection against the weather. | Raincoats, umbrellas. |
| Heat from the sun. | Temperature. |
| Clothing. | Climate. |
| **More about the sun and stars** | |
| Constellations. | Planets, meteors, comets. |
| Tides. | Seasons. |
| Time measurement. | Time Zones. |
| **Where creatures live** | |
| Life on land, in water, in air. | Adaptations for living. |
| More about kinds of homes. | Birds and their nests. |
| Men's houses. | Building materials. |
| **Man as a social animal** | |
| Cloth. | Clothing. |
| Food, production and supply. | Farming. |
| Water supplies. | Heat and light. |
| Communications. | Transport. |
| **More about the earth and its crust** | |
| The barometer. | The upper air. |
| Weather-forecasting. | Rocks, minerals. |
| Metals, other common substances. | Mining. |
| **More about properties of substances** | |
| Hardness. | Sinking, floating. |
| The 'spring' of things. | Transfer of heat. |
| Solids, liquids, gases. | Magnetism, use of magnets. |
| **Fire, and more about the effects of heat** | |
| Change of state. | Change of substance. |
| Insulation. | Ventilation. |

More about muscles, machines, engines
- Work, force, power.
- Slopes, ladders, wedges, levers, wheels, wheel and axle, pulleys.
- Wheelbarrows, carts, bicycles, rollers.
- Looms, sawmills, typewriters, sewing-machines.
- Tractors, automobiles (cars and lorries or trucks).
- Railway engines, aeroplanes, ships.

Electricity
- Torch, lamp, headlamps, battery, sparks, lighting.

Light
- Various sources and properties.

Remember that the items listed are *not* the titles of lessons. You do not start to try to teach about farming, or a tractor, or an aeroplane, or a loom. If these things are known to your pupils, and can be examined closely, you may use them, or parts of them, as examples:

(*a*) as the basis of some problem;

(*b*) to help in solving a problem;

(*c*) as an illustration of a principle or the application of a principle.

Keeping this in mind, you may be able to link up the topic with lessons in another school subject, such as geography. Then you may be able to build up a lesson, or series of lessons, around such topics as:

A lifetime; length of life.
The 'balance of Nature'.
Travel and transport.
Food supplies.
The struggle for life and the need for careful preservation.
The conservation of natural resources.
Man is able to live almost anywhere on earth.
The sea (or the land, or the air) as a great storehouse.
Man's use of heat (or light, or sound, or electricity, etc.).

CHAPTER IV

# Teaching Science in the First Year

## INFORMAL TALKS

Informal talks and discussions should play an important part at this stage. Many good schools start each day with fifteen minutes for 'Morning News' or 'Exchange of Ideas'. The teacher asks children to tell the class anything of interest which has happened at home or on the way to school. Such news will be varied; perhaps a new baby has arrived, or father has killed a big snake, or a boy has found a brightly coloured beetle, which he has brought to school wrapped up in a handkerchief. The teacher's part is to promote a lively interest; to ask questions that stimulate thought and further observation; and to encourage shy or backward children, so that all may take part. Where the class is large, the teacher should keep a notebook in which he records daily the names of the children who contribute some 'news'. Thus he will find out which children never speak, and he will then be able to give them special encouragement. Such talks make for friendly relations between teacher and pupils; they encourage the children to speak freely, and make them feel that school and home are not two separate worlds. The subject matter will usually concern the children's environment, which will thus become part of their Elementary Science course.

It is essential for free discussion that the children should speak in their own language, and, even in bilingual schools, the teaching in the first year will sometimes be in the language that the children speak at home.

## THE NEED FOR AN ELASTIC PROGRAMME OF WORK

Young children find it very difficult to picture or think about what they cannot see. With young children, it is particularly important to be ready to change the plan of lessons in order to make use of special opportunities. If a storm is seen approaching and the class has not yet done the work on 'Rain', then it would be reasonable of the teacher to say to himself: 'The next lesson is Reading, but never mind, we will have a Reading lesson instead of tomorrow's Science period, and do Science NOW.'

## LIVING THINGS

*Main ideas to be brought out*

(1) Plants are living things.
(2) Animals, people and plants are all living; they all need water, food and air.
(3) There are big and small plants. Trees are big plants.
(4) Plants (including trees) grow from seeds.
(5) There are many different kinds of seeds and they are scattered in different ways.
(6) Plants have roots, stems, leaves and flowers.
(7) Animals care for their young; many of them make homes.
(8) Birds make nests, lay eggs and care for their young.
(9) Animals live in many different places; on land, in water, in trees and under the ground; in our own homes.

It is not advisable to deal with the above ideas in the order in which they are set out. They are general ideas to which the teacher gradually introduces the children throughout the year. The sequence of work does not matter very much at this stage: what does matter is to adapt the lessons to the seasons, and to make use of chance opportunities, as suggested under 'The need for an elastic programme of work'.

Since the children will be new to their present school, a good starting-point for the year's work would be:—

*'Our school'*

Discuss its good points:—

(i) We have *classrooms*. Ask for the disadvantages of holding all lessons in the open air.
(ii) We have *desks*. Discuss here other useful classroom furnishings.
(iii) A *playground*.
(iv) *Trees*. Of what use are these to man?—to other animals?
(v) Beautiful *shrubs* and *flowers*.
(vi) *Water* for drinking.
(vii) *Latrines*.

Other points may occur to the teacher, or he may have to omit some of the above if the school lacks them. As far as possible *use the children's own suggestions*. The talk about things outside the school will test what they have observed. You may say: Are there any trees in our school grounds? Where? What kinds? If the pupils have not noticed the trees, do not *tell* them what they have failed to observe, just say: 'I shall ask you about trees another time; see what you can find out at playtime.' Alternatively, you can take the whole class out, towards the end of the lesson, and then *ask them to tell you* what they notice, giving them information only when they are unable to supply it.

In this lesson pupils should be led to appreciate that:—

(*a*) Many things have been provided for us at school; they cost money.
(*b*) We must help to keep our school in the best possible condition, and not spoil the desks, plants, etc.
(*c*) We must always make proper use of the latrines; this is a most important way of keeping our school clean and the children healthy.

From such a starting-point the teaching may be continued in various ways. Here are two suggestions:—

A. A discussion on '*How to make our classroom brighter and more attractive*' could lead to the idea of growing plants in boxes or pots. This would lead on to the work suggested for this first year on seeds and plants.

B. The discussion about trees and flowers in the school grounds could lead to a further study of '*Some plants in and around our school*'.

Select two or three named trees and two named shrubs or hedge-plants. In a tropical forest area these might be Silk Cotton (*Eriodendron anfractuosum*) and Flamboyante or Golden Mohur (*Poinciana regia*); Hibiscus and Croton (*Codiaeum*). There is plenty of material here for a number of valuable lessons. When planning them remember the following points:—

(*a*) We do NOT teach technical terms and structural details to small children; so we do NOT use or teach such words as 'compound and simple leaves', 'stamen and pistil', otherwise children merely 'label their ignorance' with big words.

(*b*) We DO aim at getting the children to use their own eyes, to learn to make comparisons and to think about their surroundings.

(*c*) They should learn that, although plants may vary considerably in size and appearance, they all have stems, leaves, flowers and roots, and that they can all grow from seeds. An outline of an early lesson in such a series is given here.

### *Specimen lesson*

TEACHER: Last week we talked about some of the good and useful things provided for us at school. Can you remember them?

The *Children* are called on to reply.

T: Those trees which give us shade—can you name the ones we saw? We are going outside to find out more about them.

(Teacher groups the class in view of a Flamboyante and a Silk Cotton.)

*Discussion* follows:—How tall the Silk Cotton is: contrast its long, straight trunk with the short trunk of the Flamboyante. Can you climb a Silk Cotton? Why not? A Flamboyante? Why?

T: We are getting hot standing here. Why?

CHILDREN: We are in the sunshine.

T: How can we get cool and still continue our lesson out of doors?

C: We can stand under one of the trees.

Discuss which tree is better for shade and why. After moving into the shade discuss why it is cooler. We are in the *shadow*: something is hiding the sun from us; the *leaves* are hiding the sun. Notice how a tall tree with a very straight trunk gives less shade than a smaller tree with a short trunk and long branches.

T: Can you tell me if there is any time when a tree can give no shade from the sun?

Children may suggest the dry, or cold, season or may say 'When the leaves fall'. The teacher then calls attention to the Neem Tree (*Azadirachta indica*), which almost always gives shade, and asks the children if they can say why.

It is because the leaves of this tree do not all fall at the same time.

Ask the children what shady trees grow near their homes.

T: Do you think these trees were always as big as they are now?

*Discussion* brings out that they were once small trees and that they keep growing bigger. Then follows the question: 'How did the trees come to be here?' Perhaps somebody planted them.

Talk about digging a planting hole, bringing good soil, and caring for the growing tree. The question of how the tree actually began is sure to arise, so the teacher will be able to find out if the children realize that a tree usually starts as a seed. Explain why we should treat trees carefully and not damage them.

Such a lesson is planned for the beginning of the course when the children are new to the school. It is designed to help them to think about what they see, and to describe it in their own words: they are being introduced to the idea of contributing to the lesson, instead of waiting for the teacher to tell them everything. Although few *facts* have been taught, the following ideas should now be familiar to them:—

1. Trees are alive; they grow; they are plants.
2. Trees have leaves, but some trees lose their leaves in the dry, or cold, season.
3. We can plant trees, but it means hard work, and they take a long time to grow.
4. We should therefore take care of our trees and not break off branches or make cuts in the trunk.

This lesson as it stands may not be suitable for your school; it is for you to modify it and to think out others on similar lines. Flowers and fruits were not mentioned: they should be discussed when they can be observed. The problem of how the tree begins was only touched upon: after completing the lessons on trees and shrubs it will be easy to get the children interested in growing their own trees. Flamboyante and Neem germinate particularly easily; some seeds can be started in boxes and others in the class- or school-garden. At the end of the year those which are doing well can be transplanted, and the children can watch them grow throughout their stay at school and perhaps after they leave.

*Plants*

*What they need and how they grow.* Every child should plant seeds and watch them grow into plants. Keep the work as practical as possible and make full use of informal discussions either during, or after, the practical work. Aim at bringing out the following ideas:—

1. Seeds need water to start them growing into plants.
2. Plants have roots which are usually under the soil.
3. Plants have stems and green leaves which are above the soil.
4. Plants are alive. They must have water, sunlight and good soil to keep them alive and make them grow well.

One lesson can be spent in planting bean seeds. Put some in glass jars; line the jars with a roll of blotting-paper or cotton cloth and fill the space in the centre with sawdust or clean sand. Slip the beans down between the glass sides and the paper or cloth; put a small amount of water in the bottom of the jar and see that the beans do not fall down into the water. Plant other beans in pots or tins of good soil and some more in pots of sand. Keep one of the glass jars and one of the pots in a cupboard or dark place. Appoint children to water the growing seedlings. Examine the seeds in the glass jars daily and watch for the first appearance of the seedlings in the pots. When the seedlings have healthy green leaves, compare them with those that have been in the dark. Thus show that a plant needs sunlight for healthy growth. Later in the term the children will see that the plants growing in pure sand do not do so well as those in good soil. At this stage just give the explanation that in good soil there is food for the plant. So the children begin to understand that our crops in garden and field need rain, sunlight and good soil.

Let the children also grow some plants in their class-garden. This will enable them to follow the complete life cycle of at least one plant. Suitable plants would be Balsam (*Impatiens sp.*)

or African Marigold (*Tagetes erecta*), since they complete their life cycle in a short time. If a crop plant is chosen, select one that is grown from seed (rather than from cuttings) and gives a quick yield. Okro (*Hibiscus esculentus*) or Egg-Plant (*Solanum melongena*) would be preferable to one of the beans or pulses, since these latter are being grown in the classroom.

*Collections of flowers and of seeds*

These should be made while the work on plants is being done. The flower collection will be temporary; it will help the children to learn the names of some more plants and show them the great variety of flower shapes, colours and sizes. Seeds can more easily be preserved and the class can arrange a small exhibit (see 'Collections', Chaps. III and V). After the collection has been made, there can be a lesson spent on drawing together what has been learnt from it. The children should now realize that:—

(*a*) Some seeds form in the flower (Marigold).
(*b*) Some seeds are hidden in the fruit (Okro).
(*c*) Some seeds are grains (Rice).
(*d*) Some seeds are the 'stones' in fruits (Mango).

They will also find that there are seeds with wings, hairs and spines, which help in scattering them.

*Animals*

Lessons on common domestic and wild animals usually occupy much time during the first school year. Too often the matter and method are in a style considered suitable fifty years ago. Common mistakes are:—

(*a*) Undue emphasis on the more obvious external features.
(*b*) Undue emphasis on the uses of the animal to man.
(*c*) Use of unsuitable pictures: e.g. of a breed of sheep entirely unlike the sheep known to the children.
(*d*) Use of unsuitable stories taken from foreign books.

These mistakes reflect the teacher's failure to regard the animal as a *living* creature and his failure to make sufficient use of local material.

What, then, is the more modern approach? We think first and foremost of the living animal, its needs and its behaviour; we relate these to its general structure (i.e. to its appearance and external features). Then we relate this particular living animal to other animals and to ourselves, showing that its needs are similar to ours. The way to study an animal such as the cow or fowl, and the way to prepare lessons on them, is something like this:—

1. *Watch* the animal *yourself* on as many occasions as possible. For example, watch cows as they eat, drink, switch away flies, walk, lie down and get up. Watch them being milked and feeding their young.
2. As you watch, *think*; think about the facts you know concerning cows and connect them with what you see. You know that cows have long, rough tongues; connect this with the way they grasp and tug the grass. You know they chew the cud; did you notice which way their jaws move?

   Did you see the ball of cud travelling up the throat? The animal first swallows the chewed food and later the ball of cud passes up again. You know they use their tails to brush away flies; did you notice that they also shake off flies by twitching their skin in a way which is impossible to man? And so you can continue. In this way you start from behaviour and relate structure to it.

Ideally the children should follow the same order: watch first, then connect (with the teacher's help) the way the animal is made with the way it behaves. In practice, however, they may not be able to watch the animal in class, but must be asked to watch at home. The uses of the animal to man should be discussed, but should not be considered of such primary import-

ance as the observational work just outlined. Clearly you will sometimes have to teach about wild animals that cannot be so closely observed, but the domestic animals afford an opportunity for developing the right approach. If the older children keep animals, these will be useful for lessons with the younger children.

*Pets.* When dealing with animals that are kept as pets, be cautious in the use of books, since many of them will have been written for countries where animal pets, especially the cat and dog, are looked after and loved in a way that is unknown in many parts of the world. If the dogs familiar to the children are half-starved creatures, scorned and often ill-treated, picking up odd scraps of food in the village to keep themselves alive, you should still start with these local dogs for your first lesson. Afterwards you may tell of dogs in other countries where they are well fed and looked after, so that they become true 'friends of man' and show great faithfulness and cleverness. You should avoid giving a lesson such as 'The Dog as a Friend to Man' if it may seem to the children to have nothing whatever to do with the dogs they know.

In all lessons about animals stress their need for water, food, exercise and sleep: their need is like ours. The necessity for more *kindness to animals* is very great, and it is only by realizing that their needs are similar to ours that this kindness can be achieved. In particular, the cruelty of keeping an animal all day without water often needs emphasis. The question: 'Which would you dislike most, to go without water for a whole day or to go without food?' will bring home to the children the suffering often imposed on some animals, especially on fowls to be killed for food, thrown down with legs tied together and kept for long hours without a drink.

Keeping birds in small cages is another common form of cruelty. Ask the children how they would like to live in a room so small that they could only sit down and never stand up or run

about? That would correspond to the kind of life to which birds in tiny cages are condemned. Since you are not likely to have a large wired enclosure in which birds can fly about, perch and nest, the best thing is not to keep birds in captivity. Parrots, however, do seem to have a liking for human beings, and, once tamed, a parrot with clipped wings can be allowed a good deal of freedom.

*Animal stories.* In many countries there is a wealth of folk-lore connected with animals, and it is not unusual to introduce these traditional stories when teaching nature study to young children. But the value of these stories is aesthetic and moral, rather than scientific, hence they find a better place in language lessons. If animal stories are to form a sound basis for nature study, they must:—

(i) be probable, i.e. be about such things as would actually occur in nature;
(ii) introduce certain features and facts which the children should know.

If the story fills these requirements, then personification of the animals (making them talk and think like human beings) is a permissible inaccuracy which can be allowed at this early stage; for to young children it will seem quite natural, and the time for learning that the truth is otherwise will come later.

Many books have appeared in European countries and in North America with stories about the animals found there. There is great need for similar books in other countries and until more such books appear the local teachers must compose their own stories. It is to be hoped that any teacher with the power *and* the knowledge will write books suitable for his own country. Note especially that a gift for story-telling is not enough; every story must be based on sound and detailed knowledge of the animal's way of life.

Suppose you wish to tell a story about the *Owl*. First jot down

facts about the owl which you wish to bring out, or which you have already discussed and wish to revise in the form of a story; for example, the bird:—

(*a*) hunts by night;
(*b*) nests in holes in trees;
(*c*) sees well at night, but not in daylight;
(*d*) has soft feathers which make noiseless flight possible;
(*e*) catches mice and small animals by means of sharp, curved beak and claws.

Then proceed to weave a simple story around these facts: e.g. 'The sun had just set and night was falling. Mother Owl awoke from her long day's sleep and peeped out of the hole in the big tree that was her home. "Ah," she said, "it will soon be dark enough for hunting." "Yes, yes, Mother," clamoured the little ones in the nest beneath her, "go quickly, we are so hungry." "A few minutes longer, my children; the light is still too bright for my eyes and I cannot see comfortably." A little later Mother Owl flew silently away; her feathers were so soft that she made no sound with her wings and there was nothing to warn the little mice in the grass of the danger approaching them. Suddenly her quick eyes noticed a slight movement and a tiny, shining eye. In a flash she swooped down, then quickly up again, gripping in her claws a small field mouse. . . .'

It is left to the teacher to complete the story. Note that all five points have already been introduced. At the end one of the children can be asked to re-tell it, the class correcting mistakes or omissions. Alternatively the teacher may question the class.

*Further suggestions for learning about animals*. The ideas summarized under 'Main Ideas 7, 8 and 9' (p. 56) should be brought out gradually by means of lessons and stories about different kinds of animals, and also by finding and watching a variety of living creatures. Arrange many nature walks and outdoor lessons. Encourage the children to find and bring to school

insects and other small animals ; never mind if you cannot give names to most of them (see Chapter II on 'Identification'). 'It's an insect', or 'It's the young one of an insect', is quite enough information for a child who as yet has only a vague idea as to what an insect is. Stimulate observation by asking such questions as: 'Where did you find it?' 'Do you think it lives there?' 'Do you know what it feeds on?'

Use every opportunity of taking the children to watch animals at work. Here are three examples:—

1. Go and watch a colony of weaver birds at work, nest-building. Let the children discuss such questions as:
   'What do the birds use for nest-building?'
   'Can you say how the mother birds differ from the father birds?'
   'Do they both help in nest-making?'
   'Do some birds hide their nests?'
   'Do you think the weaver bird's eggs and young ones will be safe, for their nests are not hidden at all?'
   'What other animals live in trees?'
   'Are they all birds?'

The children will like to make pictures of a tree with weaver birds' nests in it.

2. Go out and watch ants at work. Ask:—
   'What are the ants carrying out of their home?'
   'Where do they put the grains of earth?'
   'Have you watched a man dig a hole?'
   'Where does he put the earth?'
   'Are ants bringing anything into their home?'
   'What are they bringing?'
   'What other animals live under the ground?'

3. Visit a pond when there are frogs.
   'Do frogs live under water?'

'Can they swim?'

'Do they stay under water all the time?'

'What part of them do we see above the water when they are swimming?' (nose and eyes).

'Can the frog come out of the water?'

'Do you know any animals that stay under the water all the time?'

## HEALTH ACTIVITIES

There should be no formal instruction about health during the first two years, and no lesson periods should be set aside for health teaching. The formation of *good health habits* is, however, of vital importance, and there are various practical *activities* which will help in building up the right ideas about healthy living.

The teacher aims at the formation of good health habits by means of:—

(*a*) The daily inspection.

(*b*) Supervising the children in matters of personal hygiene.

(*c*) Getting the children to help in keeping their classroom and school neat and clean.

(*d*)[1] Various other practical activities such as: making toothbrushes; learning to cut finger- and toe-nails; washing clothes; folding clothes neatly; making a bed; making sweeping brushes; helping to boil water for drinking, cleaning water pots, making covers for water pots.

(*e*) Short, incidental talks on matters relating to health.

(*f*) Health plays (occasionally).

[1] Taken from 'Syllabus of Instruction for African Schools'. Primary. Tanganyika Territory.

## EARTH AND UNIVERSE

### *Weather*

Weather variations are best dealt with by informal talks and discussions as suggested at the beginning of this chapter. Marked seasonal changes such as the breaking of the Monsoon, or the first rainstorm after prolonged drought, will call for special lessons. The children should observe what happens, and talk and think about it, rather than learn reasons for weather changes which are too difficult for them to understand *at this stage*. Here is an example of such an informal discussion:—

TEACHER: It feels nice and fresh this morning; can you tell me why?
CHILD: It rained last night.
T: Were you asleep all night?
C: Yes.
T: Then how do you know that it rained?
C: The ground is wet.
T: Let us see how many changes we can notice because of the rain last night.

From the replies of different children, the teacher might put the following list on the blackboard:—

Pools on the paths; water dripping from the trees; dry dust on the paths has changed to slippery mud; a nice, fresh scent in the air; some leaves that looked tired now look fresh again.

Continuing the discussion the teacher might sum up: 'The rain was very welcome; we shall have more water to drink and for washing; it has helped the plants too, they can grow better now. The birds and animals are glad also, because they too must have water to drink. Suppose we write an "R" on the side of the blackboard for every rain-storm and see how many we get before the end of the term?'

Under the term 'Weather' we include at this stage the topics Wind, Clouds, Rain, Water on the Earth.

*Main ideas to be brought out*

(1) Air is something real; although it is all around us we cannot see it, but we can see what it does.
(2) Wind is moving air. How to tell wind direction.
(3) Wind can be useful or harmful.
(4) Water 'dries up' and goes into the air and then we cannot see it; it becomes *water-vapour*.
(5) Clouds consist of very many tiny drops of water floating in the air.
(6) Rain falls from clouds when the water-drops become too large to float in the air.
(7) Rain-water produces pools, streams, lakes and rivers. Most rivers run into the sea eventually.

### (*1*), (*2*) and (*3*). *Air and wind*

*Observation and discussion.* We *see* clothes blowing on the line, leaves and branches moving, smoke blowing sideways, sails of boats filling out, kites being carried into the air, clouds moving (but these do not always tell us the direction of the wind near the ground).

We *feel* the wind pressing against us, especially when running or cycling in the opposite direction.

*Wind is sometimes helpful:* it cools us; brings rainclouds; moves sailing-boats; helps fires to burn; helps clothes to dry.

*Wind is harmful* in storms: breaking trees, blowing off roofs, spoiling crops, causing sandstorms and rough seas.

*Practical work*

*a.* Blow through a straw or thin, hollow piece of bamboo. Can you see anything coming out? Now blow with the end of the tube under water and thus show air bubbles. Have the

children seen anyone looking for a small puncture in a bicycle tube? Why is the tube dipped in water?

*b.* Watch such things as clouds, smoke, sailing-boats, dust clouds, moving leaves and branches. Can these things move by themselves? What moves them? Contrast the appearance of a flag, or of clothes hanging from a line, on a still day and on a windy day.

*c.* Use a fan to move small, light objects. Discuss uses of fans: e.g. they make a wind to cool us, help fires to burn, and are used in winnowing grain.

*d.* Find the direction of the wind on a fairly calm day by wetting the finger and holding it up. Explain that as water 'dries up' it makes things cool. The wind makes the water dry more quickly on one side of your finger than on the other.

*e.* Wave a piece of cardboard and feel the resistance of the air. Talk about walking against a strong wind.

### (4)–(7). *Water-Vapour, Clouds and Rain*

*Observation and discussion.* When we hang out clothes to dry, where does the water go to?

What happens to the rain-water left in puddles?

How do we know when rain is approaching? We see dark clouds which are called rainclouds, and sometimes we feel the air turn suddenly cooler because of a cool wind which is blowing the clouds along.

What is it like inside a cloud? (This question can usually be answered only by children in a forest or mountainous region, where thick cloud-mists are common: those who have not experienced this can be told about it.) The air seems to be very wet; we cannot see far; drops of water cling to our hair and to our clothes.

Of what is rain composed? *Drops* of water.

What happens to rain which falls on the ground? Some sinks in and helps plants to grow; some appears again later on hillsides as *springs*; some runs downhill and forms little *streams*;

these join to form *rivers*. Rain collects to form dirty *puddles* and clearer *pools*; very large pools are called *lakes*. Eventually, most water reaches the *sea*.

*Practical Work*

*a.* Ask a child to clean the blackboard with a damp cloth. Watch it dry. Where does the water go to? We cannot see it; it has gone into the air; it has changed into *water-vapour*.

*b.* Take two similar handkerchiefs or pieces of cloth; dip them together into water, squeeze them hard, then separate them; put them side by side in the sun, one spread out, the other folded in four. Compare the time each takes to dry.

*c.* Take a narrow glass jar and a wide shallow pan or calabash. Measure the same small amount of water into each. Find how long it takes for the water to dry up in each vessel.

*d.* Take two cigarette-tins. Put one large spoonful of water into each. Stand one in the sun and one in the shady classroom. Find how long the water takes to dry up in each case.

*e.* Make two similar large wet spots on the blackboard, putting them some distance apart. Fan the air near one of the spots and see which dries first.

*Conclusions.* From the above experiments and from the children's general observations, show that air, sunshine and wind all help to dry things; they help to make water change into water-vapour.

*f.* Watch rain during a storm; observe rain-drops. Place a pan outside and see how much water you can collect. Watch the formation of puddles. Watch water running down sloping paths, forming tiny streams and carrying grains of soil. See how the soil is deposited when the ground becomes more level and the flow of water becomes slower.

*Note:* Do not use or teach the word 'evaporation' at this stage.

### *The sun*

*Introduction.* Remember that it is not possible for the child to form many correct ideas about the universe as the result of his own observation. He will naturally conclude that the earth is very large, the sun and moon small; as small in fact as they 'look'. He has no way of telling that they are shaped like balls, nor any idea how far away they are. He does see that they appear to move, while it is certainly apparent to him that the earth does not move. He may think of the sky as a kind of roof with the stars as holes to let in the light. Other children may have different, equally interesting ideas. These ideas are not to be laughed at or brushed aside: the children should be led gradually, by means of observation and discussion, to understand what view men take of the universe today.

*Main ideas to be brought out*

(1) The sun is a fiery ball, very large and very far away.
(2) The sun rises every morning in the East and appears to climb higher in the sky. At noon it is nearly overhead. Then it appears to descend until it sets in the West in the evening.
(3) Usefulness of the sun. It gives us day and night. We can tell time from the sun. It gives us light and warmth. It helps plants to grow. It dries things. It draws water into the air.

Give general talks about the sun and what it does for us. Make general observations on the apparent path of the sun throughout the day, so that the children get a clear picture of how the sun seems to move. With young children there is no need to dwell on the fact that the sun does not really move round the earth; they will return to the subject later when they can understand more. Link the talks with village activities at different times of the day and with the behaviour of animals and birds in the early morning, at noon and in the evening. Tell how such people as farmers, fishermen and hunters can tell the time of day by observing the position of the sun in the sky.

Such talks will lead on naturally to:—

*Shadows.* A first lesson on shadows can be as follows. Choose a place out-of-doors and make a drawing of the same pupil's shadow at different hours of the day; it can be drawn on sand or soft earth, or with chalk on a hard surface, or even marked

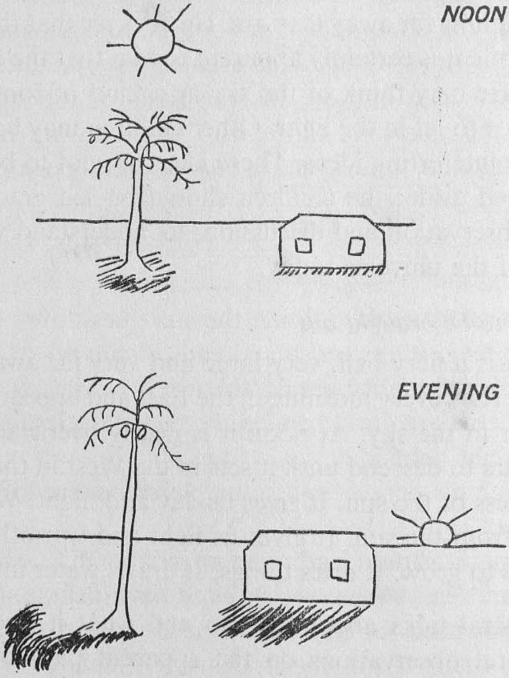



FIGURE 16.—A child's drawing to illustrate shadows at noon and evening.

with small stones. Point out how the shadow changes in length and direction as the sun travels across the sky. Children should make drawings to illustrate the results.

In connexion with this lesson there should be discussions about changes in size and direction of shadows of trees and buildings, and the children can make pictures to illustrate 'Morning', 'Noon' and 'Evening'. The illustration in Figure 16 must

*not* be put on the blackboard by the teacher for the children to copy; it is intended to give an indication of the type of drawing to expect from first-year children. (See the section on drawings by young children on p. 23.) Instead of asking the children to copy a drawing, discuss with them the following questions:—

'How will you show that it is morning in your first picture?'
'How will you show that it is noon in your second picture?'
'How will you show that it is evening in your third picture?'

All of them can indicate the positions of the sun and the lengths of the shadows; those who like drawing may add a person engaged in some evening task or resting at midday.

### *Day and night*

*Main ideas to be brought out*

(1) The sun gives us day. When the sun goes down it is night. A day begins at sunrise and ends at sunset.
(2) It is cooler at night because the sun is hidden.
(3) Some nights are dark, some quite light. Moon and stars are our night lights.
(4) Men, animals, insects and some plants behave differently in the day and in the night.

The last point should lead to an interesting discussion, drawn from the children's own experiences. It may include such points as: Sleep, our need for it; children need more than adults. Do all animals sleep? If so, when? Think of animals that sleep by day and others that sleep at night. Do the same with insects. When we sleep we do not feel hungry or thirsty. How much do we move when asleep? We go on breathing, so we need fresh air. Do plants sleep? Not in the sense that men and animals do, but some plants close their leaves at night. e.g. the Rain Tree (*Pithecolobium Saman*).

*The moon.* Quite small children are deeply interested in the moon. In this first year the teacher can guide the children in

their observations, and can answer their questions without giving difficult explanations. Discuss and illustrate the shape of the moon as noticed at different times: there is no need, during this year, to make a series of observations. Look for the moon during the day; why does it seem so pale? Compare with a candle in bright sunshine.

Let the children make pictures of 'Full Moon Night'.

Have cut-outs pinned up in the classroom to show: new moon; the moon growing bigger; full moon; the moon growing smaller.

*The stars* need not form the subject of special lessons. They may be discussed as occasion arises, and the children will learn that they are 'suns' that are very, very far away. They give light when there is no moon; the blackest kind of night is a cloudy, moonless one, when even the stars are hidden.

### THE SHAPE OF THE LESSONS

How are you trying to build up each lesson, and to develop a series of lessons? Has your class understood the need for practical work? How have you and the class decided what to observe and what experiments to do? Have you kept in mind the basic aims of science-teaching?

The chief aims include trying to help children to learn to think and to gain skill in solving problems. This means that each lesson should have a definite 'shape': it should be built up to a pattern. You should draw out from the children, through their *questions* and your *questioning*, a clear, simple *statement of a problem* to be solved during the lesson. *What is already known* about it should be summarized, and then the class should help to decide on ways of finding out more. Thus you arrive at the best means of making an *experiment*. The *results* of the observations or experiments are next examined, and then you have to decide (with the children) what *conclusions* can safely be made from them. You may be able to arrive at a *principle*, and to study briefly some of its *applications*.

Have you approached your lesson-topics in this way? It is only by such a method that science teaching can have meaning and value. Regard every lesson in every year, and especially the practical work, in this way. As teachers, we cannot be reminded too often of our aims, and of the best ways to attain them.

## CHAPTER V

# Teaching Science in the Second Year

### LIVING THINGS

*Main ideas to be brought out*

(1) All fruits grow from flowers.
(2) Most fruits contain seeds.
(3) Seeds contain food and a tiny plant.
(4) The parent plant supplies the food in the seed.
(5) Some new plants grow from stems (cuttings), some from underground foodstores. *Buds* can grow into new shoots.
(6) Various parts of plants serve as food for men and animals.
(7) Some animals lay eggs, others give birth to living young.
(8) Animals change as they grow up. Some animals have young that are quite unlike their parents.
(9) Animals usually move about in search of their food. They run, climb, swim, fly, crawl or jump.
(10) Animals and plants prepare themselves for the Dry (or Cold) Season.

#### (*1*) *and* (*2*). *Flowers, fruits, seeds*

Last year the children collected flowers and learnt some flower names. Let them continue the same work this year, in an informal way, by bringing flowers to brighten the classroom and by observing new plants when they are out for nature rambles. They will already have the general idea that a flower comes before a fruit.

*Growth of fruit from flower*. This can be a very interesting subject if the children follow out the stages themselves. Ripe, edible

fruits will appeal to them, so it is a good idea to start from these. For the first lessons choose plants which have flowers and fruits in varying stages of development in the same season, e.g. lime, orange, banana, tomato.[1]

Bring one or two ripe and unripe fruits. Start with the ripe fruit. 'Where did this come from?' Then show the unripe one of the same variety. 'How does this one differ from the ripe fruit?' Try to think of all the differences; these will include size, colour, hardness, amount of juice, taste. Now see if the children can trace the story backwards:—The fruit grew and ripened; where did it begin? How big was it? What did it look like? If they cannot answer all these questions do not supply the answers; keep to the idea of 'Let us find out'. You should either take the class out to visit a tree on which you know there are both flowers and fruits, or, if no tree is near-by, you should have flowers ready, one for each child if possible. Then set them to answer the questions.

'In which part of the flower did the fruit begin?'

They can do this best by looking at the tree bearing very young fruits and then looking at the flower, for the young fruit always closely resembles the pistil. It is important that every child should open a flower and find the seedbox.

Note that you should *not* teach the parts of the flower and their functions, nor should you refer to fertilization. It will be convenient, however, to teach the word *petal*. If the children ask about the other parts, give them the names sepal and stamen, but there is no need for them to make a point of memorizing these terms. Tell them (if they inquire) that the yellow dust (pollen) helps the seedbox to grow into a fruit.

By means of further lessons convey these two ideas:—

1. *All* fruits grow from the seedbox of a flower.

[1] It does not matter if you choose a plant that has separate male and female flowers. The children can look at the male flowers and discover that they have no seedbox; then they learn that a flower that has no seedbox cannot have a fruit.

2. Some fruits get dry as they ripen, instead of getting juicy. We call them 'fruits' also.

Introduce the class to a dry fruit of the bean family. (If beans are not available, the ornamental shrub, Pride of Barbados (*Caesalpina pulcherrima*), provides an excellent example.) Spend one lesson studying the stages in ripening, for it is a strange idea that 'ripening' can sometimes mean becoming dry and hard. Open the flowers and find the tiny pod-like seedbox; then look at soft, green, half-ripe pods; then at hard dry ripe pods containing full-grown seeds. Make drawings (as records). (See Chap. III, on the child's sense of proportion.)

Next have a nature walk to collect fruits and examine different flowers to find the seedbox.

*Further practical work*

(i) In connexion with gardening, notice the time of flowering and the gradual ripening of fruits in the school-garden.

(ii) Harvest seeds from crops in the class-garden. Select the best seeds and store them for future planting.

(iii) Observe and try to name any birds or animals seen eating fruits. Ask the children to get information from home about animals and birds that raid fruit gardens.

(iv) Select some seeds from oranges, and papaya (paw-paw) or other common edible fruits. Plant them and watch the growth of the young 'trees'. How soon do the young seedlings show the characteristic leaves?

(v) Make *collections* of fruits.

This year the children can do more in the matter of arranging (classifying) their collections. They should make labels, and learn to take a pride in orderly arrangement and cleanliness. There is no need to keep to the kind of classification which you find in botany books. (See Chap. III, on 'classification of collections'.) The fruits could be grouped as follows:—

(*a*) Fruits we eat.

(*b*) Fruits we use as vegetables.
(*c*) Fruits whose seeds we eat.
(*d*) Poisonous fruits.
(*e*) Fruits with no special use to man.

If you like, the more formal classification can be added:—

(i) Juicy fruits.
(ii) Dry fruits that split.
(iii) Dry fruits that do not split.

### (*3*). *Seeds contain food and a tiny plant*

Most children in school see the inside of a bean; too often their first-hand study of seeds begins and ends with beans. This shows lack of energy and initiative on the part of the teacher. Let them open as many seeds as possible and gradually come to the discovery that all seeds contain a store of food and a tiny plant. Of course many seeds are too small for the children to dissect; others become too hard. Nuts, however, can be cracked and the kernel examined; some 'stones' such as those of Neem can be studied before they become hard and ripe; other seeds like peas and beans are soft if freshly picked, or can be soaked if they have become dry.

'Cotyledon' is a long word; it is better at this stage to say 'seed-leaf', for this is an accurate equivalent.

*Practical work*

*a.* Supply one bean for every child. Soak the beans for 24 hours before the lesson, adding a little formalin, if you have any, to the water to prevent unpleasant decomposition. Use the largest kind of bean available; Sword Beans (*Canavalia ensiformis*) are best, but Lima Beans (*Phaseolus lunatus*) serve quite well. Bring a pod containing beans; then you can show that the *scar* is the mark left by the very short stalk which attaches the bean to the pod. It is best to supply pins to help in opening the beans. Let the children find the *seed-coat*, *seed-*

*leaves*, and *young seed-plant* consisting of *seed-leaves* and *seed-root*. Do not teach any other terms.

*b*. Make collections of seeds. They can be arranged as:—

Seeds with prickles or hooks.
Seeds with wings or hairs (flying seeds).
Seeds that are 'stones'.
Seeds that are good to eat.
Seeds used in games.
Seeds used as beads.

Other groups can be made to suit local requirements.

*c*. Use the seed-collections and other seeds supplied by the teacher to examine various seeds for seed-leaves and a tiny plant. If there are Neem trees near-by, the children will enjoy finding the brilliant green embryo; to do this they have to get half-ripe fruits in which the stone has not yet become hard; they can squeeze out the embryo between finger and thumb. The seeds of corn and other grains are difficult to study at this stage. Explain that there is one seed-leaf which is very small because it has no food stored in it; the food-store is outside the seed-leaf.

*d*. The seed-collections will show that some plants have large seeds and some have extremely small ones. Collect some very

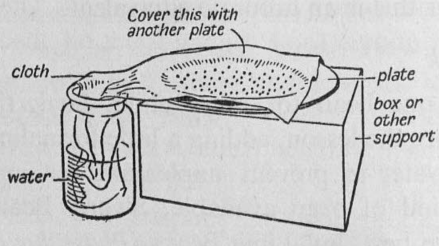



FIGURE 17.—How to germinate seeds on a cloth

small seeds of garden flowers or vegetables: it is difficult to believe that these tiny, seemingly dead things contain a living plant. Sow some in shallow vessels and watch their germination.

Germinate others on a piece of cloth, as in Figure 17.[1] Use a second plate to cover the cloth.

*e*. Examine the fruit and seed of Avocado (Alligator) Pear (*Persea gratissima*). The seed-coat is thin and sticks to the flesh of the fruit. Germinate a few seeds by placing them on glass jars containing water which just reaches the base of the seed (Figure 18). Keep them in a dark cupboard. Also keep one in the light and see if you notice any difference. When the leaves appear, keep all the seedlings in the light.

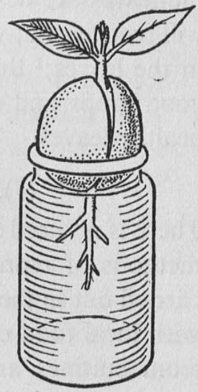


FIGURE 18.—Germination of the seed of Avocado Pear

When root and shoot are well grown, plant them in the garden. Throughout the experiment draw attention to the very big seed-leaves which make up the main part of the seeds. Why do they decrease in size?

*f*. Germinate some beans in sand or 'red earth'.

As soon as they appear above the surface, carefully cut off the cotyledon from half of them (using scissors). Leave the other seedlings untouched, but give them all the same amount of water. Compare the growth of the two groups of plants. Explain the results.

*g*. Have an exhibition called '*Useful Seeds*'. This may include seeds used for human food, animal food, oil, medicine, spices.

*(4). The food in seeds is supplied by the parent plant*

The children have watched fruits as they ripen; they have seen the seeds swell as they become full of food. Ask if they have ever thought about how the food gets into the seed. It is supplied by the parent plant *for the seed-plant*, not for man. The children have seen beans attached by stalks to the pod; the seeds take in food through these stalks. Where was the food

[1] Or use a 'rag doll' seed-tester. The open plate method, however, makes it easier for the children to make frequent observations.

made? Have they ever seen crops or fruit-trees which have been attacked by caterpillars or locusts? What happens when most of the leaves are destroyed? A small plant may die; a larger tree will recover, but will yield a very poor crop. Plant food is made in the leaves;[1] there must be plenty of food if we are to have good crops and strong seeds, so our plants must have many healthy leaves.

### (5). *Plants from cuttings and tubers*

There is no need at this stage to give formal lessons on different methods of reproduction. The work should be practical and carried out in the school-garden. It should be closely connected with local food crops. Let the children grow some crop plants from cuttings and from tubers. Although they may not be strong enough for deep digging, they can grow a few plants and follow the complete life cycle.

When planting tubers find the *buds*; keep a tuber in moist soil in the classroom. Observe growth of buds. Find buds on stems; observe growth of buds into branches and leaves. Then explain that the tuber is an underground *stem*, because it bears buds.

If possible visit farms and see different crops being planted.

### (6). *Plants provide food for animals*

With the help of the class draw on the blackboard a table of foods that we get from leaves, stems, roots, fruits and seeds. (There is no necessity to distinguish between roots and underground stems here.) The plant has its storehouse of food in different parts, but especially in its seeds and in its underground parts. Sometimes the plant's food-store is good food for man; sometimes we find it unpleasant, or even poisonous. Emphasize that green leaves and fruits provide valuable human food.

*Practical work*

Organize an exhibition of 'Food from Plants' arranged according to the parts of the plant we eat.

[1] Do not attempt any explanation at this stage.

There are animals which damage our crops by eating some part of the plant. Have some lessons on plant-eating animals. Here are a few suggestions, but every teacher must select local examples.

### PLANT-EATING ANIMALS

*Animals that eat leaves*

Elephants
Hares (often mistakenly called Rabbits)
Flying Foxes (or Fruit-eating Bats)
Snails
Grasshoppers

*Animals that eat roots*

Wild pigs
Porcupines
Rats
Ground Squirrels
Mole Crickets

*Animals that eat fruits*

Elephants
Monkeys and Baboons
Squirrels
Civet Cats
Palm Civets
Many kinds of birds
Flying Foxes (Fruit-eating Bats)

*Animals that eat seeds*

Weaver birds and many other birds.
Mice.

*(7), (8) and (9). Habits and life histories of animals*

These ideas are not to be treated in special lessons. They are guiding ideas for the teacher to keep in mind as he plans lessons on animal life. His first aim is to interest the children in some of the common animals. Wherever possible the life history should be followed.

*Practical work*

*a. Keep caterpillars* and follow the life history of a butterfly or moth in all its stages. (See Chap. III.)

*b.* Get the fresh egg-case of a Praying Mantis. Keep it in a jar or box covered with mosquito net until the young emerge (if you are lucky you may see them come out). Then set them free, as you cannot feed them. They serve as an example of an insect whose young resemble their parents.

*c.* Keep tadpoles and follow the life history of the toad or frog. (See Chap. III.)

*d.* Make observations on the life-history of the domestic fowl.

*e.* Some animals which are difficult to feed may be kept in the classroom for short periods.

### (10). *Seasonal preparations of plants and animals*

In the Tropics the difficult season for living things is usually the Dry Season. In this sense it corresponds to the Cold Season of temperate regions. As the Dry Season approaches take note of the ways in which plants prepare for it; e.g. shedding leaves, scattering seeds, dying-down of the shoot leaving a food-store underground. The preparation of animals is not so easily observed; some toads bury themselves in the soil and 'sleep'; many insects such as mosquitoes seem to disappear; they are often hiding in dark, damp places; birds do not nest and many which will be brightly coloured in the nesting season are now in dull colours.

## HEALTH ACTIVITIES

As for the First Year; see Chapter IV, p. 68.

## EARTH AND UNIVERSE

### *Weather*

A very simple form of class weather-chart can be kept. It need not be continued all through the year; if the children begin to

lose interest, it is best to stop. Start the chart at a season when the weather is variable. Agree on a very simple system of symbols to indicate different kinds of weather and appoint small groups of children to look after the chart week by week. An imaginary chart for one month with entries for 1½ weeks is shown in Figure 19. Since it is often impossible to sum up a day as 'sunny' or 'rainy', it is best to divide each day-space on the

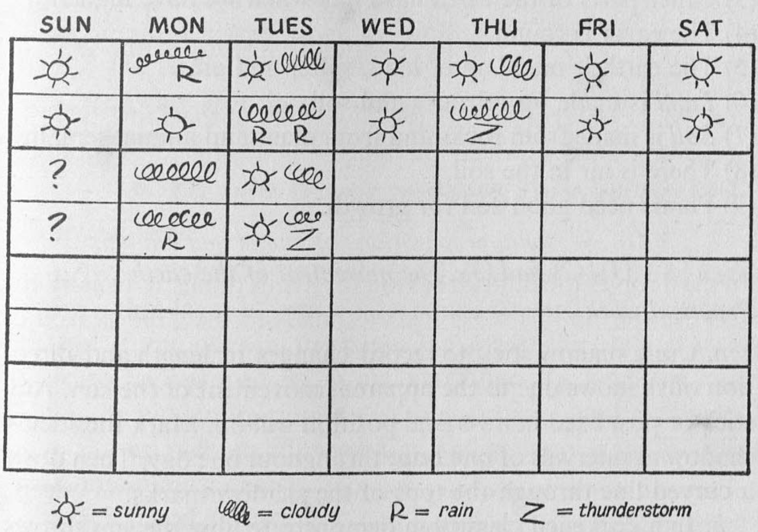



FIGURE 19.—A simple weather-chart

chart and enter up records at the end of morning and afternoon school.

Take every opportunity during this year of pointing out, in the course of discussions, how the behaviour of people, animals and plants is connected with changes in the weather. Farming operations take place according to the season; fishermen know when certain kinds of fish will be plentiful; and so on. Most plants shed their leaves during the dry season, while some animals, such as the toad, go to sleep, buried in loose soil.

### *Sun and earth*

*Main ideas to be brought out*

(1) The earth is shaped like a ball. It turns round once in every 24 hours.
(2) *Day and night* depend on the movement of the earth. The sun only *appears* to move.
(3) Other parts of the earth have day when we have night.
(4) The earth is round.
(5) The earth is made up of land, water and air.
(6) *Land* is made up of rocks and soil.
(7) *Soil* is made from rocks and from plant and animal remains.
(8) There is air in the soil.
(9) Plants need good soil for growth.

### (*1*), (*2*) *and* (*3*). *The movement of the earth*

*Practical work*

*a*. Use a shadow stick to record changes in length and direction of shadows due to the apparent movement of the sun. Any stick or post fixed in a vertical position will do. Mark the stick's shadow at intervals of one hour throughout one day. Then draw a curved line through the tops of the shadow marks.

*b*. In a darkened classroom demonstrate how the sun throws light on each part of the earth as the latter turns. Use a *candle* as the sun, and any large *ball* or nearly spherical *fruit* as the earth. A white, or light coloured, object shows up the shadow better. Make a mark on the 'earth' to represent 'our own country' and see when it is at 'sunrise', 'noon', 'sunset' and 'midnight'. Consider children living in some other part of the world 'just going to bed as we get up' and so on. There is no need in this demonstration to discuss the movement of the earth around the sun.

### (*4*). *The shape of the earth*

There is no need to spend time discussing the various *evidences*

for the roundness of the earth with children of this age. Tell them that people have found that the earth is shaped nearly like a ball, although men used to believe that it was flat. Sailors feared to travel too far over the sea lest they should fall over the edge of the earth. Now men in aeroplanes fly all round the earth quite quickly. Some children will say, 'The earth does not seem to us to be round.' If possible let them feel balls or globes of various sizes and notice that the larger the ball, the less curved does the surface seem to be. Now think of a ball the size of the earth; the curve is so slight that we do not notice it. With children living near the sea, discuss and draw on the blackboard the appearance of ships moving near the horizon.

### (5). *The earth is made up of land, water and air*

*Practical work*

*a.* Take a *ball of clay*. Paint it roughly to show land and water. Wrap a thin layer of *cotton-wool* round the ball; this represents the air. If you were on the moon looking at the earth, it would seem to be wrapped up in air, and often the land and water would be hidden by clouds. (There is no air round the moon.)

*b.* Put up pictures showing land and water, e.g. lakes, rivers, seas, mountains, deserts.

*c.* Tell travel stories.

### (6) *and* (7). *Land, rocks and soil*

*Practical work*

*a.* If possible take the class to some place (e.g. a road-cutting) where they can see rocks and the overlying soil, as in Figure 20. Let them make coloured pictures to show: rock, broken rock, lower soil, upper (good) soil, plants.

*b.* Make a *collection* on the science table to show: *rocks* of various kinds, rounded *pebbles* from seashore or river bed; *sand*, *clay* and *mud*; good soil and poor soil.

*c.* If soft rock is available, crush some and compare the product with sand and with soil.

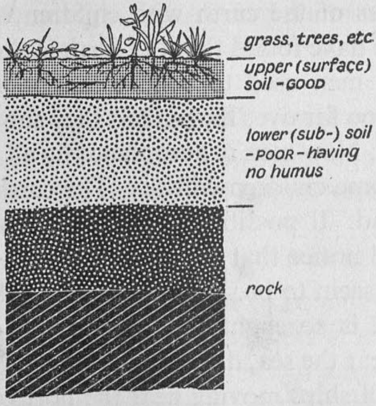



FIGURE 20.—Diagram of the side of a road-cutting

*d*. Near the seashore observe the action of waves on rocks, stones and sand. Around lagoons, tidal rivers, etc., notice how the water has spread soft, black mud.

## (8). *Air in the soil*

*Practical work*

*a*. To show that there is *air in the soil* put some good *soil* in a *glass jar*. Pour water on it quickly and notice the bubbles of air escaping from the soil. Discuss the animals that live in the soil and their need for air.

*b*. Keep some *earthworms* in soil *in a large tin*. Pour on plenty of water, and notice how the worms come up for air. Ask if the children have noticed that earthworms and other animals which live in the soil come up to the surface after heavy rain.

*c*. Take two similar healthy plants in pots. Give one excessive water; give the other only enough water to keep the soil moist. The plant in the first pot becomes unhealthy because the water has pushed out the air from the soil.

## (9). *Plants need good soil*

Make the work *entirely practical*. Grow two lots of beans: one

in good soil (with much humus), the other in poor soil (lacking humus). Compare the results.

### *The moon*

The phases of the moon should be observed and discussed, but no reasons for them should be given at this stage.

*Main ideas to be brought out*

(1) The moon is shaped like a ball; it is not so big as the sun and is much nearer the earth.

(2) The moon seems to change in size and shape during each month. There are four weeks between one full moon and the next.

It may be difficult to convince the children that the moon only looks as big as the sun because it is so much nearer to us. Every teacher should draw on the children's own experiences in looking at distant objects, in order to make them realize the effect of distance on apparent size. Suggested examples are a fishing-boat far out at sea; a building on a distant hill; cows far away on a plain; a vulture hovering high in the air; a lorry approaching along a road that can be viewed from a mile or more away.

Observations on the moon must be done chiefly at home, and should be used for discussions and making illustrations at school. This will be an opportunity to gain the parents' interest in what their children are learning, for the children will ask them questions in the evenings. The brilliant full-moon nights of the tropics usually play an important part in village life, and the teaching may well start from talking about 'our activities in the evening when the moon is full'; then contrast a 'black', moonless night. Questions for the children to answer might be:—

When does the full moon rise and set? Will it rise at the same time the next evening? And the next?

After full moon, how does the moon's shape change?

What is the shape of the new moon? When and where can we see it?

Can the moon ever be seen by day?

Why does the moon look so pale when we see it in the day-time?

If the children ask for an explanation of the changes which the moon undergoes something on the following lines would be suitable at this stage:—

'The moon gives no light of its own as the sun does. The moon is cold and dark, and it only shines when it is lighted by the sun. Look how brightly this tin lid shines when I hold it in the sunshine; now I put it in the dark cupboard, and it does not shine any more. Sometimes the moon turns the whole of its lighted side towards us on the Earth; then we say, "It is full moon." Sometimes the lighted side is turned away from us; then we might say that the moon has its back to us. Its back is dark; it does not shine, so we do not see it and we say that there is no moon. The next night we see a very tiny part of the shining side of the moon and we say, "There is the new moon." Each day we see more of the shining side so that the moon seems to grow bigger until we have full moon again.'

*Practical work*

Keep a class record for one month of the changes in the moon's appearance.

CHAPTER VI

# Teaching Science in the Third Year

## LIVING THINGS

*Main ideas to be brought out*

(1) All living things need water and air.

(2) Plants take in water through their roots; it passes up the stems to the leaves.

(3) Plants give off water from the leaves in the form of water-vapour.

(4) Leaves of different plants vary greatly in size, shape, colour, texture and smell.

(5) Animals usually drink water through their mouths; they go in search of water.

(6) Roots grow downwards; stems grow upwards.

(7) Animals have many ways of protecting themselves from their enemies.

(8) Some plants have special means of protection.

### *(1) and (2). The need for air and water*

A general title for ideas (1)–(4) might be 'Living things need water'. The need for air receives less attention at this stage, but the fact should be mentioned whenever suitable opportunity offers. Notice that certain characteristics of water will also be studied this year (see p. 109). Take these lessons either before the ones on Living Things, or arrange them at times when they will best illustrate the work connected with plants and animals. For instance, experiments on evaporating water must precede those on loss of water from leaves.

A. *Living things need water and air*

Bring out this idea gradually; do not teach it separately.

B. *Water enters the plant through the roots*

Quite a number of children think that water enters a plant through the leaves as well as through the roots. They can investigate this by means of the experiment suggested below.

Avoid referring to the roots as 'the mouths of the plant'; a mouth is an opening which leads into the food tube of an animal; there are no openings in the roots, nor do they 'swallow' water. If the children ask: 'Have plants (or roots) got mouths?' say: 'No, plants don't drink as we do; they are able to make the water keep on soaking in through the skin of the tiniest roots; only the very small, young, roots can do this; big, hard, old roots cannot take in water at all.' Do NOT refer to osmosis at this stage.

*Practical work*

*a.* You will need some young plants in pots or tins for some of the experiments. Let the children sow the seeds and care for the seedlings, and make these activities the opportunity for some important incidental teaching. For instance, if Balsam seeds are used, let the children 'harvest' them and observe the very effective device for scattering the seeds. Discuss what they learnt in previous years about the scattering of seeds. The preparation of the 'flats' and pots should give rise to such questions as:—

*Why do we have holes in the bottom of a flower-pot?*

*Why put a layer of small stones in the pot before putting in the soil?*

*Why must we not press the soil too tightly?*

(Refer to, or repeat, the experiment done last year to show that soil contains air.)

Transplanting seedlings into pots or tins will lead to questions such as:—

*Why do we move the plants?* Children may say that they are 'too close' or 'haven't room to grow'.

This is correct, but is only a partial answer. Leave some plants undisturbed in the 'flats' and continue to water them. Compare their growth with that of the plants which have been moved. The ones in the 'flat' become thin and weak; they cannot get enough food.

*b. To show that plants take in water through the roots and not through the leaves.* Take two similar healthy plants growing in pots. Give each the same amount of water daily, but water only the roots of plant A and only the leaves of plant B. Figure 21(*a*) shows one arrangement by which you can prevent the water

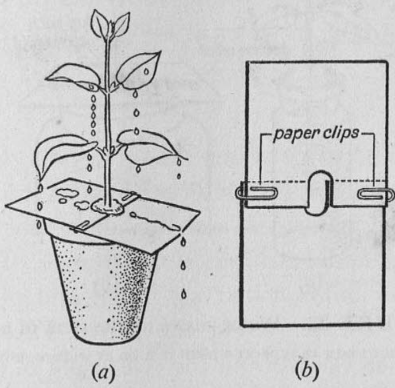



FIGURE 21.—To show that a plant does not take in water through its leaves

The two pieces of card, cut as shown in (*b*), are clipped round the stem and the hole plugged with cotton-wool. If the card is fixed in a sloping position the water runs off.

from reaching the roots of plant B. If possible use also a third plant, C, which receives no water at all.

*c. To show that water passes up the stem to the leaves.* Have ready one or two jars or wide-mouthed bottles, about three-quarters full of water coloured with red ink. Carefully dig up some young Balsam plants and *very gently* wash some of the soil from their roots. Support a plant in each jar as shown in Figure 22. By the following day, or perhaps by the end of the same day, the leaf *veins* will be stained red. Cut the stems into

short lengths and pass these round the class; the fine tubes through which the water passes are stained red.

*d.* Try out variations of the last experiment. Stand the following in coloured water: a shoot bearing white flowers; a young stem of maize or sugar-cane; two similar shoots of the same kind of plant, one bearing leaves and the other with the leaves removed (this should show that the leaves help the water to pass up the stem).

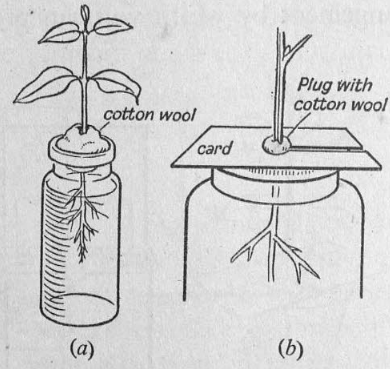



FIGURE 22.—Water passes up the stem of a plant
(*b*) shows how to support a plant in a tin or wide-mouthed jar.

## (3) *Leaves give off water*

At this stage we do not give formal teaching about transpiration; the word 'transpiration' must not be used at all. Our present aim is for the children to get a clear idea of how water circulates through plants; they then begin to arrive at two other important ideas, namely, that plants draw up water from the soil, and that plants help to keep the air moist. They will return to these ideas next year.

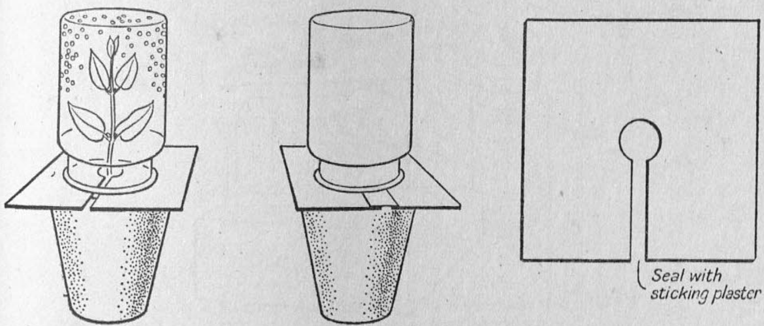
The children have been watering plants in pots. Ask them: 'How much water have you given to a plant each day?' 'How much in a week?' 'Where has this water gone?' 'Suppose we have two pots of soil, one containing a plant and one with no

plant; let us give the same amount of water to each pot. What is the result?' (Do experiment *a.*)

We know that some of the water goes up to the leaves; what happens next? We cannot see water flowing out of the leaves: can we explain this? If the children are able to supply the right answer get them to suggest how they could show that the water is given off from the leaves.

*Practical work*

*a.* Take two similar pots of soil, one containing a plant and one without a plant. Give the same quantity of water to the




(*a*) (*b*)

FIGURE 23.—How to show that leaves give off water

(*b*)—Cut the card like this, or as in Figure 21(*b*).

soil in each pot every day and keep them side by side. Why does the soil in the pot with the plant become dry more quickly?

*b. To show that leaves give off water into the air.* Use a growing plant, not cut shoots. Cover the soil with pieces of card or tin-foil cut as indicated (Figure 23), then water from the soil cannot evaporate freely into the jar. Do not omit the control experiment, otherwise the children may say that the water which they see inside the jar came from the air inside it. Place both pots side by side in the sunshine and examine at intervals during the day.

Here is an *alternative method* of doing the experiment if you

have not got a jar large enough to cover your growing plant. Enclose a leaf growing on a shrub in a glass bottle as indicated in Figure 24. (A large-size 'Gloy' bottle will do.) The teacher must select a suitable shrub or plant before the lesson, and must think out how to support the bottle so that its weight will not break the leaf-stalk. Bore a hole in the cork large enough to allow the leaf-stalk to rest in it without being crushed; then cut the cork in half lengthwise. When fitting up the experiment take great care not to damage the leaf-stalk; notice the angle that it makes with the stem and remember that the bottle has to be supported at that angle. Wrap a small piece of cotton-wool

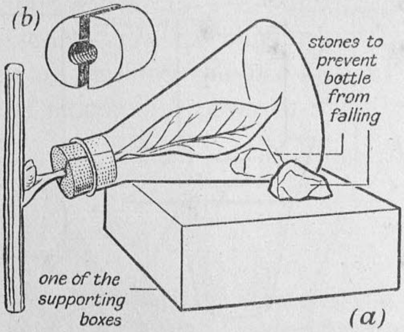



FIGURE 24.—Another way of showing that a leaf gives off water
(*b*) shows how to cut the cork.

round the stalk and enclose it inside the split cork. Hold this in one hand and bring the bottle near; get a child to push the leaf gently into the bottle and then insert the cork. Continue to hold the bottle in position until the support has been arranged. Place an empty corked bottle beside the first one.

*Discussion on this experiment*. Where has the water inside the jar come from? Show clearly that the only way that water can enter the jar is by the plant stem (or leaf-stalk in the second method). Picture the water coming from the soil, into the roots, up the stems, into the leaves and out into the air. Do we see it coming out? Do we see water leaving a dish that is set in the

sun? No, because it comes out in the form of *water-vapour*, but the air in the jar becomes so full of water-vapour that it can hold no more and some changes back into drops of liquid water. Show the class a vessel which holds a quart or a litre of water. A large sunflower plant may lose this quantity of water in one day. Now think how much water a great forest sends into the air each day!

### (*4*). *Recognizing plants by their leaves*

The teacher is particularly warned NOT to teach botanical terms other than 'simple' and 'compound' leaves. No child of this age should be expected to give a formal description of a leaf (nor of anything else); but a child's powers of observation can be quickened and trained without requiring verbal descriptions. He can become quick to notice differences in shape, colour,

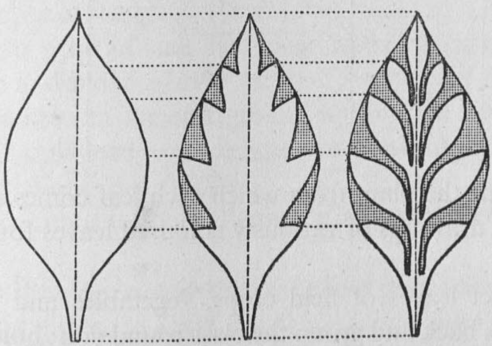



FIGURE 25.—Paper cut to show types of leaves. (Cut away the shaded parts.) (*a*) and (*b*) are simple leaves; (*c*) is a compound leaf.

vein-arrangement, texture (i.e. smooth, hairy, or waxy surface; leaf as whole—tough or soft). He can become expert at identifying leaves, and the plants from which they come, long before he is capable of accurate verbal description.

It is necessary to explain the meaning of simple and compound leaves. A practical way is by cutting paper with scissors,

showing how the compound leaf is really one leaf which has become cut up into what appear to be separate leaves (see Figure 25).

*Practical work*

*a.* Take the class out and get them interested in discovering which is a 'whole leaf' (compound), and which only part of a leaf (leaflet). Show them that there is a bud or young shoot where a leaf joins the stem; such a bud is never found on any of the stalks which form part of a compound leaf.

*b.* Make a collection of fresh leaves in jars of water. They can be arranged on the Nature table thus:—

| FEATHER VEINS | | FINGER VEINS | | STRAIGHT VEINS |
|---|---|---|---|---|
| Simple | Compound | Simple | Compound | |
| | | | | |

Try to name the plant from which each leaf comes.

*c.* Make drawings of variously coloured leaves found in your district.

*d.* Collect leaves of field crops, vegetables and fruit trees. Bring them back and group the class round you; hold the leaves up one by one: see if they are now recognized. Note special characteristics—e.g. scent, hairs, milky juice.

*e.* Have a leaf-naming competition. Divide the class into groups; each group chooses a writer who has paper and pencil. Separate the groups so that their members can talk to each other without being overheard. Give each group a piece of paper with 6–10 leaves pinned to it. Let them write the names and see which group gets most right (no marks off for bad spelling.)

### (5). *Animals need to drink water*

Before this lesson, ask the children to watch different birds and animals drinking and to find out:

1. How they take up the water.
2. Where they go for water.

Some animals take up small quantities with their tongue (they *lap* up water); examples are dogs and cats. Others put their mouths into the water and appear to suck it up; horses and cows do this. Ask a child to illustrate the position taken up by a horse, cow or dog when drinking; he is unable to do this satisfactorily. Why? His neck is much too short. Think of animals and birds with long legs. Do they also have long necks? How does an elephant drink? And a hen? Does a snake drink? And a lizard? Stress the need of animals in captivity for a proper supply of water.

Where do wild animals find their water? If possible visit a water-hole and make a study of the footprints of animals and birds to be seen in the soft ground around the hole. In some areas this should lead to some interesting lessons on the animals of the district and their habits.

Take this opportunity of discussing our own need for water.

### (6). *Roots grow downwards; stems grow upwards*

The work should be almost entirely practical. Ask the children: 'When we plant beans and corn does it matter which side of the seed is uppermost?' They ought to know the answer, but have they stopped to consider how surprising it is that, whichever way up the seed is planted, the roots always grow downwards and the shoot (leaves and stems) upwards?

*Practical work*

Germinate some beans or cow peas and some corn in glass jars as in Chap. VI, pp. 82–3.

Put them in different positions. Observe daily. When roots and shoots are pointing downwards and upwards respectively, carefully take out some seedlings and put them back with the roots pointing upwards and the shoots downwards. Next lesson make drawings of the result. A pair of forceps is useful for lifting the seeds; be very careful not to touch the root-tip, which is easily damaged.

Figure 26 shows another way of doing the experiment. A straight seedling is placed horizontally on damp blotting-paper in a bottle. It is pinned to the cork to keep it in position. The bottle is then put in a dark cupboard and looked at every hour or so. This method allows more freedom for the growth of root and shoot, but with young children the first method is satisfactory because they can assist in the planting and there are more seedlings for them to watch.

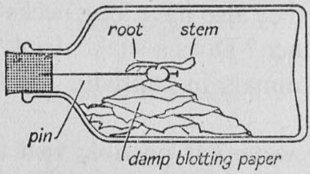



FIGURE 26.—One way of showing that stems grow upwards and roots downwards

### (7). *Protective devices among animals*

This is a subject dealt with in many books on nature study. The teaching sometimes becomes too formal because lessons deal only with textbook examples and do not make enough use of animals which the children can see and handle. Whenever you have the class out-of-doors take every opportunity of pointing out examples of the ways in which animals escape notice, either by being coloured like their surroundings, or by some other device such as resemblance to a dead leaf. The children will soon be far quicker than adults at noticing well-concealed animals. In flowers there are often spiders of just the same colour as the petals; on the bark of trees you may find moths and other insects which closely resemble a piece of bark. Stick insects are common in some countries; leaf insects not uncommon. Grasshoppers are well concealed by their colouring, and some, when at rest, resemble a blade of

grass. Tree snakes and tree frogs are usually green in colour. On the sea shore and in open country many examples will be found, e.g. bush-fowl and their young are difficult to distinguish from dead leaves; young shore crabs are the colour of the sand, but, as they grow bigger and are better protected by hard shells, they assume brighter colours.

Below are a few suggestions for animals which might be studied, but each teacher must adapt the work to his particular area.

| *Method of protection* | *Example* |
|---|---|
| *a*. Claws, horns, teeth. | Leopard. Hawk. Buffalo. |
| *b*. Poison. | Snake. Scorpion. Wasp or Bee. |
| *c*. Hard coverings. | Crocodile. Tortoise. Snail. |
| *d*. Swiftness of movement. | Antelope. |
| *e*. Concealment (escaping notice). | Chameleon. Stick insect. |

Remember that many animals have more than one means of protection: e.g. snakes, including poisonous ones, escape by swiftness of movement: they only use their poison if they cannot escape; many animals possessing horns and hoofs will escape by running, but can turn and attack their pursuer if necessary. The crocodile uses its teeth for defence, in addition to its protective armour.

*Snakes*. Children should learn to recognize the dangerous ones.

### (*8*). *Some plants have special means of protection*

Find plants which have:

*a*. Thorns.
*b*. Milky juice (sometimes poisonous)
*c*. Stinging hairs.

## HEALTH ACTIVITIES

Continue the practical work as outlined for Years I and II. In addition give simple lessons on the following subjects:—

1. Cleanliness of the body. Clean habits.
2. Cleanliness of clothing.
3. Our need for fresh air and sunlight.
4. Cleanliness of our surroundings, both at home and at school. Tidiness. Care of mats and blankets. Cockroaches: their life history and how to deal with them.
5. Cleanliness of our food, eating utensils and cooking vessels.
6. Clean drinking water.
7. Care of eyes, ears and teeth.
8. Care of cuts, scratches and sores.
9. The Housefly: its habits and life history, and the dangers to health due to flies.
10. 'Safety First' drill in places where there are dangers due to road traffic.

## EARTH AND UNIVERSE

### *The earth and the sun*

The ideas developed in Year II now receive rather fuller treatment.

*Main ideas to be brought out*

(1) The earth turns round once in 24 hours. This movement causes day and night.

(2) The sun seems to move from East to West, but in fact it is the earth which turns from West to East.

(3) The turning of the earth makes the sun, moon and stars seem to rise, move across the sky, and then set.

(4) The earth travels round the sun. The time taken to complete one journey round the sun is called a year.

### (*1*) *and* (*2*). *The rotation of the earth*

*Practical work*

On a sunny day go out and draw round the edges of a shadow in the playground. Place a few stones about 6 inches outside the shadow on each side and along the top. Will the shadow cover any of these stones later? Which ones?

Move the class away and spend a short time revising the points of the compass. Draw a cross on the ground to show N., S., E. and W. Ask the pupils to name the direction of well-known objects and landmarks. Thus they discover that we need names for directions in between the four main points. They learn the eight points of the compass and use them in indicating direction.

Go back and observe the position of the shadow. To which side has it moved? Why? Has it got longer or shorter? Why? Ask the children to say where and what shape the shadow will be by the end of the school-day. Put stones to indicate the predicted shadow. Come back to see how nearly right their estimate was.

### (*3*). *Rising and setting of the sun, moon and stars*

*Practical work*

*a*. Revise Expt. *b*, page 88, emphasizing that the earth turns from West to East. Take away the ball and put a child to represent the earth. As he turns from West to East he should notice that the 'sun' appears to move in the opposite direction. Discuss travel by lorry, train or boat; objects appear to move past us, but we are moving and they are still. So the movement of the earth makes the sun appear to move in the opposite direction.

*b*. Observe the moon, either by day or night. Which way does it seem to move? Why?

*c*. If possible get the children to observe at home a bright star, or a well-known constellation, near the eastern horizon,

and another near the western horizon. They can then see that the stars appear to rise and set as do the sun and moon.

*(4). The earth's movement round the sun*

First revise the names of the months and their order in the year.

*Practical work*

*a.* In the playground draw a circle. Divide it into 12 as for a clock face; each division is one month. One child represents the sun; a second holds a fruit or ball on a pointed stick to represent the earth; he must make the ball spin round as he walks slowly round the circle. See if the class can call out the month names as the 'earth' travels on its one-year journey.

*b.* Discuss the farmwork done at different times of year. Draw a circle on the blackboard and divide it into months; let the children name the months as you write them. Go over the work done on the farm as the earth travels through the year. Ingenious teachers with a gift for drawing can use this idea, combined with handwork by the children, to make an exhibition.

*Note:* For simplicity two important things have been omitted from the above demonstrations: the moon and the tilt of the earth's axis.

*c.* Organize a demonstration to show the *earth* spinning on its own axis while it slowly revolves round the *sun* and also to show the *moon* revolving round the earth. Do not forget that the moon must always turn the same face to the earth. Draw a face on the ball which represents the moon, and then the child who holds the ball will find it easy to keep the right position.

## *Air*

*Main ideas to be brought out*

(1). Air occupies space.
(2). Air is needed for burning.

### (*1*) *Air occupies space*

*Practical work*

*a.* Take a glass jar and ask, 'What is inside this jar?' If the children answer, 'Nothing,' say that you think there is something inside. If they say, 'Air,' ask how they could show that there is air inside.

Plunge the jar mouth downwards into a deep bowl of water. Water will not enter the 'empty' jar.

Tilt the jar sidewise and watch air escape. Now water enters the jar.

*b.* Repeat the last experiment, but 'pour' the escaping air

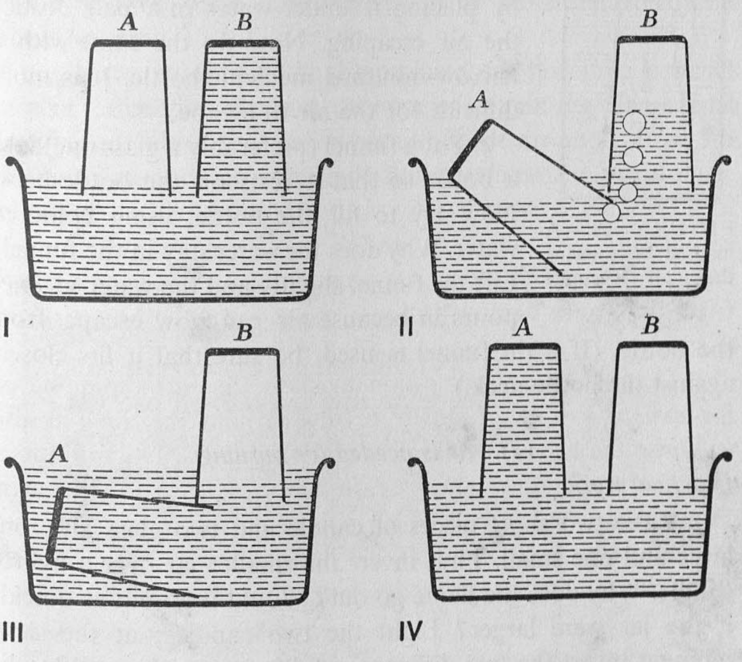



FIGURE 27.—'Pouring' air

I. Fill jar B with water by lowering it sideways into the bowl. Lower jar A, mouth downwards, into the water.
II. Gently tilt A until its edge is below the edge of B. Then B will catch air as it escapes from A.
III. Continue to lower A until all the air has been transferred to B.
IV. Raise A to its original position: it is now full of water.

into another inverted jar which you have previously filled with water (see Figure 27).

*c.* Use clay or candle wax to fix a match upright inside the bottom of a glass. Push the glass mouth downwards into a deep pan or bucket of water. The experiment is more interesting if the water is deep enough to cover the glass (Figure 28). Lift the glass out, being careful to keep it upright all the time. Dry your hands. Take out the match and strike it. It burns, although it took a trip under water. The air in the glass prevented it from getting wet.

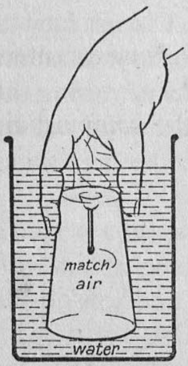



FIGURE 28.—A method of showing that air occupies space

*d.* Fill a wide-mouthed bottle with water by placing it under water in a pan. Notice the air escaping. Now do the same with a narrow-mouthed medicine bottle. It is more difficult for the air to escape.

*e.* Put a funnel (preferably a glass one) into a bottle so that it rests on the bottle-neck. Now try to fill the bottle, using coloured water. Why does the water stay in the funnel? Lift the funnel slightly and the water at once pours in because air can now escape from the bottle. (If a tin funnel is used, be sure that it fits closely against the bottle-neck.)

### (2). *Air is needed for burning*

*Practical work*

*a.* Take two short pieces of candle and two glass jars, one large and one small. First invert the smaller jar over a lighted candle. Why does the flame go out? Would it go out as quickly if the jar were larger? Light the two candles; at the same moment invert the two different sized jars over them. Why did the candle in the larger jar burn longer?

*b.* Stand a lighted candle on the table and place a lamp chimney over it. Why does it go out? Re-light the candle and

this time raise the chimney on three coins or matches. Why does the candle now burn well?

Take a kerosene lamp; examine the holes by which air enters and make comparisons with the last experiment.

*c.* Observe and discuss methods of making fires for cooking. Note especially the ways of admitting air and of increasing the air supply when more rapid burning is needed, e.g. blowing; fanning; bellows for a blacksmith's fire.

*d.* Make a fire outdoors and boil some water. Discuss how to arrange the paper and sticks and why it is best not to allow the pan to rest on the fuel. Discuss the best way of raising the pan and of getting a good current of air. Put the fire out by throwing sand on it. The sand keeps air from the fire; water does the same.

*e.* Discuss what to do if: (*a*) papers catch fire, (*b*) a person's clothes catch fire. Explain the danger of rushing about with burning clothing; the person should lie down and roll on the ground if there is no water or blanket at hand.

### *Water*

*Main ideas to be brought out*

(1) Water flows downhill.
(2) Water helps to change the surface of the earth.
(3) Water can be changed into water-vapour or into ice. Both water-vapour and ice can change back into water.
(4) Water usually contains air.
(5) Some things dissolve in water and some do not.
(6) Some things float in water and some sink.

Make the work mainly practical, giving only the minimum of preliminary explanation.

The work on water may be linked with the lessons on Living Things by considering '*How Water Helps Us*', e.g. water (*a*) forms rivers and seas; (*b*) enables boats to float so that we can travel by water; (*c*) keeps us alive and healthy; (*d*) gives us

good crops and juicy fruits; (*e*) keeps us clean; (*f*) enables us to cook many foods.

### (*1*). *Water flows downhill*

This fact needs no demonstration. It should be discussed and its consequences noted: e.g. why are roofs usually made sloping? In countries where there is terrace cultivation, the class should go out to observe and discuss the flow of water in irrigation channels.

### (*2*). *Water changes the earth's surface*

In many districts the action of water in changing the surface of the earth can be studied during and after heavy rainstorms and along the banks of streams and rivers. The observations can be more exact than in the preceding year. Introduce the idea of *force*; running water is powerful; it exerts force; the faster it runs, the stronger it can push. Compare the effects of strong winds.

*Practical work*

Take a large glass jar; put water, stones, sand and mud into it; stir them all well and watch how the solid matter settles.

### (*3*). *Change of state*

At this stage the changes of water from one state to another require only a few simple experiments, with discussions based on them. There will be more work on this subject next year. You can avoid the terms evaporate, condense, freeze, melt, by saying 'changes into'. This emphasizes the fact that ice, water and water-vapour are different forms of the same substance.

*Practical work*

*a*. Take three cigarette tins. Put the same small quantity of water in each. Place one in a shady place; place another in the

sunshine; heat the third in the classroom until the tin is dry. Hold an earthenware plate over the third tin while there is still water in it. Why does the plate become wet?

Where has the water gone to in each case?

*b*. Boil some water in a kettle, or, if this is not available, in an open pan. Observe the *cloud* made by steam condensing as it reaches the cooler air. (We commonly speak about 'clouds of steam', but this visible cloud is condensed steam; true steam is hot water-vapour, and this is invisible.)

*c*. Get some ice and keep it well wrapped up in cloth until the lesson, then let the children see and handle it. Put some pieces of the ice in a tin; when they have melted heat the tin until it is dry. You have thus changed ice into water-vapour.

### (4). *Water contains air*

*Practical work*

Very gently heat a glass jar of water. Notice the small bubbles of air which are given off.

Talk about the water-animals and plants which breathe this air in the water.

### (5). *Solution*

One of the most useful properties of water is its ability to dissolve so many substances. Children at this stage can get the idea that some substances seem to disappear in water, that they are not lost, however, but are evenly distributed throughout the water and in some cases can be recovered. One lump of sugar sweetens every part of a cup of water. Mention that rainwater as it sinks through the soil dissolves some substances that plants use as food material.

*Practical work*

*a*. Place the same amount of water in a number of jars. Add a spoonful of each of the following substances to the different jars: common salt, Epsom salts, powdered blackboard chalk,

oil, and any other substances that the pupils like to test. Keep the jars for the next experiment.

*b*. Put a little of each of the liquids used in the last experiment in a saucer. Add one more saucer containing pure water—e.g. rainwater. Leave them all until they dry. What remains?

Make a list of substances that dissolve in water, remembering to include air.

### (6). *Floating and sinking*

One lesson on *floating and sinking* should be enough. The general conclusions to be arrived at are:—

1. Light things float whatever their size and shape.
2. Heavy things sink unless they are shaped so as to take up plenty of space, i.e. to push aside much water. Hence a boat made of a heavy substance must be hollowed out and have thin walls.

Discuss floating things and their uses, e.g. boats, rafts, inflated skins, logs floated down rivers, floats on fishermen's nets.

*Practical work*

Ask the children to collect and bring any substances or objects which they think will float. Test the various things in a pan of water. Suggested objects: a cork, a piece of blackboard chalk, a pen-nib, a wooden spoon, a metal spoon, various kinds of wood, a punctured football bladder and a good one inflated, a piece of tinfoil, candle wax.

CHAPTER VII

# Teaching Science in the Fourth Year

## LIVING THINGS

Alternative schemes of work are given for part of the years' work. Scheme I is most suitable for town schools, while Scheme II is recommended for areas where the pupils are in close touch with farming and village life. Whichever scheme is adopted, the following should be included:—

*Main ideas and topics*

(1) The parts of the flower and their uses.
(2) Pollination by insects and wind.
(3) Decay: its importance in nature, and how it is caused by moulds, fungi, and bacteria.
(4) Fertility of the soil: how it is maintained in nature, and what we must do to secure good crops.

### SCHEME I

The underlying idea is to give an introduction to the chief large groups of plants and animals. The children should appreciate something of the great *variety of form* of both animals and plants. At the same time they should learn that there are *resemblances* which enable us to group, or *classify*, living things. It is a common mistake for teachers to lay too much emphasis on classification. This is because it is easier to learn the characteristics of different groups than to study living things. But for children it is the individual animal, or plant, and its life history, which are vital and interesting. As an illustration of the right and wrong approach, suppose that you are dealing with butterflies and the Insect group. The wrong method is seen when a teacher gives one or two lessons on 'The Life History of the Butterfly',

illustrated by pictures or blackboard sketches, which are taken from any book available, without considering whether the kind of butterfly shown is seen locally or not. An improvement on this purely theoretical method is made when the teacher brings to the class some captive butterflies, and has the children round him in groups so that they can see for themselves such features as the sucking-tube (proboscis) and compound eyes. A still further improvement is for either teacher or pupils to bring some caterpillars for examination. But the best method of all is to let the class follow the complete life history of *one particular kind* of butterfly, or, if eggs cannot be obtained, at least to start with young caterpillars and watch all the changes until the full-grown insects emerge. The same thing should be done with an insect such as the cockroach, and, while the life histories are being worked out, the class should go for walks to observe insects of as many different kinds as possible. Last of all will come a discussion on the Insects as an Animal Group, and their main features will be illustrated and learnt. By this time, the pupils should understand that each type of butterfly or moth has its own life history, the general outline being similar for all, but the details differing for each particular kind of insect.

Representative animals and plants of the following groups may be studied:—

A. *Animals*

I. *Animals with backbones*

*a.* Mammals
*b.* Birds
*c.* Reptiles
*d.* Amphibians
*e.* Fishes

II. *Animals without backbones*

*a.* Animals with jointed legs:
Insects, Crabs, Spiders
*b.* Molluscs (soft-bodied animals with shells):
Snails, Shellfish

B. *Plants*

*a.* Flowering plants
*b.* Ferns
*c.* Fungi:
Toadstools
Moulds

C. *Bacteria*

(Group-characteristics suitable for teaching to children can be found in other books.)

## A. ANIMALS

### I.*a.* *Mammals*

The children already know that some animals give birth to living young. Now let them learn that Mammals start life as an egg which is so small that we need a magnifying-glass to see it; it has no shell; it is kept inside the mother's body and grows there to a young animal, which is born alive and is then ready for independent existence.

Some unusual Mammals about which teachers may be asked are:—

(i) *Porcupine* and *Hedgehog*, which are covered with spines. Hairs are found, however, on the under side of the body and between the spines. The spines are really hairs cemented together.

(ii) *Scaly Ant-eater* (*Pangolin*) and *Armadillo*, which have scales which are formed from hairs. A few hairs are found between the scales.

Do not forget to emphasize that Man is a Mammal.

### I.*b.* *Birds*

Include some lessons on beaks and feet of birds, pointing out the adaption to different ways of life and varying kinds of food. Do not depend entirely on illustrations from a book. Always try to refer to well-known local birds as examples. Build up a collection of skulls (with beaks) and feet in the school collection.

### I.*c. Reptiles*

If time allows, study contrasting types such as the lizard, snake, tortoise and crocodile. Many harmless reptiles are wrongly regarded as poisonous: emphasize that lizards and chameleons have no poison, and that only a few kinds of snake have poison which is deadly to man.

*Practical work*

Keep a tortoise. Feed it on plantain, banana and fresh green leaves such as spinach.

Lizards, chameleons and geckos all require living insects for food and so are unsuitable for keeping at school. If captured they should be kept for observation in a cage, for one day only, and then set free.

### I.*d. Amphibians*

*Practical work*

*a.* Bring a frog or toad to class. Put it in a cage containing a shallow dish of water. Notice:—

The smooth skin, i.e. without hairs, scales or feathers.
The large, projecting eyes placed on top of head.
The very small nostrils.
The long, strong hind-legs (with webbed feet in a frog) suited for swimming in water and for jumping on land.
The movements of the throat as the animal breathes.

*b.* Keep tadpoles and follow the life history.

### I.*e. Fishes*

*Practical work*

Keep a small freshwater fish for a short time in a tank or *large* jar containing green water-weed.

Ask the children to watch the fish and to find out before the next lesson how many different movements it is able to make.

Ask them especially to notice how the fish makes itself move forward. Many people think that the fins are used as oars or paddles, but a careful observation will show that it is the movement of the back part of the body and tail which sends the fish forwards.

### II.*a. Arthropods*

Do not give the scientific name of this group. It is, however, easy for children to understand that all animals which have a hard, outside skeleton, and jointed legs, are related to each other. Most of the work will be about insects; in some areas crabs will seem the next most important members of the group; in other areas scorpions, spiders or millipedes ('Thousand Legs') will be chosen as familiar examples.

*Practical work*

Keep insects in the classroom and make records of their complete life histories. If the children have kept caterpillars in previous years, there are other insects, etc., which can be reared in the classroom. For example:—

(i) *Mud Wasp.* The building of the nest has to be watched out of school. A completed nest can be carefully removed with a knife. If possible procure several nests. Keep one in a cage or covered jar until the wasps emerge; use the others for examining the contents. A large class cannot all watch the teacher as he opens the nest; in such a case it may be well to give the lesson first, illustrating with diagrams. Then open a nest in front of the class; keep the contents of the cells separate; lay out the contents of a few cells in an orderly fashion on sheets of paper. Then the class can start to make drawings from the blackboard diagrams, and while they are at work small groups of children can come up and make a careful inspection of the demonstration specimens.

(ii) *Cockroaches.* The egg cases are easy to find, and the insects are easy to keep in a large glass jar covered with mosquito

netting: they cannot be reared in wooden cages as they escape through the cracks. The jar should not be kept in the light all day: it can have a piece of brown paper tied round it most of the time. It is easy to catch cockroaches in a trap made from a tin and a semi-circular piece of paper (Figure 29, I). Fold the paper (II) and pin it to form a cone which has the wide end turned back over the tin edge. Cut the pointed end so that you get a fish-trap device (III). Put food in the tin and lay it on its side in a place where there are cockroaches.

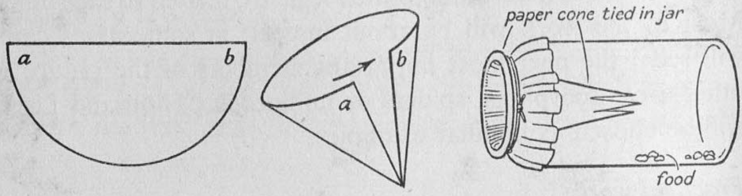



FIGURE 29.—A cockroach trap

(iii) *Cotton Stainers*. These are not so easy to rear, but at the right time of year insects in every stage of development can be collected and kept for a short time in the classroom.

(iv) *Houseflies*. Eggs and larvae (grubs) may be found in compost pits or animal dung heaps. If they are put, with some compost or dung, in a covered jar, the life history can be watched.

(v) *Scorpions*. These can be kept only if you have members of the class who will supply them with living insects. They like juicy, soft-skinned spiders and usually reject hard-skinned grass-hoppers. Scorpions dislike bright light: they should either be kept in a dark corner, or have a stone in the cage to hide under.

(vi) *Spiders and Crabs*. Observations must be made out-of-doors, though living and dead animals can be brought to class for inspection.

N.B.—*Schools near the sea*. Children can watch crabs, make traps for shore-crabs, and learn to distinguish the chief kinds.

### II.*b. Molluscs*

*Practical work*

*a.* Keep *snails* in a jar or cage with a glass side. Supply with fresh green leaves. Notice the slime tracks. Try to watch them eating, and walking on the glass side of the cage. Snails like moist air; keep damp soil in the cage.

*b.* Break open a snail shell, or use a large broken one from the school collection. Show the pillar in the middle and how the shell twists round it. Picture the animal's body twisted round, and explain why it is difficult to pull a snail out of its shell, even when the snail is dead.

*c.* (For schools near the sea.) Collect shells. Try to get some shellfish with animals inside. There will usually be limpets clinging to the rocks.

## B. PLANTS

### *a. Flowering plants*

### (*1*) *and* (*2*). *The work of the flower*

In this connexion the only terms which are necessary are: sepals; petals; stamens and pollen; pistil, stigma, ovary and ovules. Teachers will find that they can manage quite well at this stage without calyx, corolla and other botanical terms.

The facts of *pollination* and *fertilization* can be dealt with very simply. The following summary suggests what is necessary at this stage:—

*What purpose does the flower serve?* It is the means by which new fruits and seeds are produced.

*What part actually forms the fruit?* The lower part of the pistil which we call the ovary or seed-box.

*What is the work of the stamens?* They contain pollen. Without pollen the ovary can never grow into a fruit and the ovules can never become seeds. The pollen must be placed on the tip of the pistil (stigma) when this is sticky and ready to receive it. The sugary juice on the stigma makes the pollen grains grow

tiny pollen-tubes which go right down into the ovules; and once they have reached the ovules, the latter begin to form seeds and the whole ovary starts to get bigger and to form the fruit.

Sometimes the pollen simply falls on to the stigma; sometimes it is carried there from another flower by insects, which visit the flowers in search of nectar; in other cases the pollen is blown by the wind.

The children should recognize that most flowers have the parts sepals, petals, stamens and pistil. Having studied one flower, such as the Hibiscus, they ought to apply their knowledge to other kinds. If they can only find the sepals, petals, etc., in the one type they have used in class, it is a sign of bad teaching.

*Practical work*

*a.* Lesson on the Parts of the Flower and their uses. Each child, or at least each pair of children, must have a flower, e.g. Hibiscus, to examine.

*b.* Take the class outside and examine some other large flowers. Point out that:—

i. In such flowers as Pumpkin and Morning Glory the petals, and sometimes also the sepals, are joined to form a tube, thus giving better protection to the nectar, stamens and pistil. We can tell how many petals join to form the flower by counting the points at the top of the tube.

ii. The petals and sepals may not be all alike, and this often adds greatly to the beauty of the flower.

This lesson is likely to bring out two further interesting facts:—

Some plants have two different kinds of flowers, the female flowers containing the pistil (but no stamens), and the male flowers containing the stamens (but no pistil).

Some flowers have neither sepals nor petals, but they can produce fruits because they have pistils and stamens.

The children ought to *enjoy* looking at all the flowers they

can find, but the teacher must discourage careless destruction of numerous flowers.

*c.* Observe insects and birds collecting nectar. Look for the nectaries in flowers.

*d.* Make a list of the common trees in your district. Can the children describe the flowers of each tree? Arrange to make a study of *tree flowers* at the right season. Some people think that certain trees have no flowers, because these are inconspicuous. The flowers of large forest trees can often only be obtained when they fall from the tree.

*e.* Supply the children with several kinds of flowers which have a large ovary—e.g. Pumpkin, Pawpaw. Let them cut across the ovary and find the ovules inside. Ovules are unripe seeds.

*f.* Choose a suitable plant and study how the fruit grows from the flower (see Chap. V, p. 78). Notice how the sepals, petals and stamens all die and fall off when their work is done; only the pistil remains.

Draw attention to some plants in which a very small ovary changes into a very large fruit, e.g. Cocoa, Orange.

*Note:* It is unfortunate that the Hibiscus, which is widely used as a typical flower, seldom 'sets seed', i.e. it seldom produces a fruit. You will have to explain that in some cultivated flowers the pollen does not succeed in reaching the ovules, even though it is placed on the ripe stigmas. Hence the fruit cannot develop.

### *b. Ferns*

Having made clear what is meant by the term 'flower', the children will be able to contrast Ferns with Flowering Plants. The life history of the fern is complex, and a microscope is required if it is to be followed properly. All that is necessary at this stage, however, is to examine a number of ferns and see that they never bear flowers, but have minute *spores* growing in groups on the under sides of the *fronds* (or fern-leaves). Why call them spores and not seeds? Because they have not been formed

from flowers, nor did they grow within a fruit. They also have an unusual way of growing into a new fern plant.

*Practical work*

*a.* Examine fern fronds bearing spores. Put some good rich soil in a pot; shake spores over it and cover the soil with an inverted tin which has had a few holes punched in it. Keep the soil thoroughly moist. If conditions are suitable, the spores will grow into tiny, flat, leaf-like objects. The new fern plants in time grow from this little 'leaf', but they will now require light as well as a very moist atmosphere. A big glass bell-jar over the pot is what is needed, but you can try to get further growth if you have a large glass jar or lamp chimney.

*b.* In districts where ferns thrive, grow them for ornament on the verandah, in pots and hanging baskets.

### *c. Fungi*

These form an important and interesting group, though in very dry areas not much time will be spent on them. The work will be closely connected with that on Decay.

*Practical work*

*a.* Find some Fungi of the kind referred to as Toadstools or Mushrooms. Dig them up and notice the fine white threads in the soil on which the fungi are growing. Note the absence of green colouring matter. As food fungi use decaying (or occasionally living) plants or animals.

*b.* Grow *moulds* on pieces of moist yam, bread or other food. Just keep the food covered with a glass jar and watch the results. In time the stalks bearing round spore-cases will develop.

*c.* Draw attention to *diseases caused by moulds*, if any crops in your district are seriously affected. *Ringworm* is also caused by a fungus. The spores of fungi are so light that they float in the air; hence it is difficult to prevent fungus diseases from spreading.

The spores, however, usually enter a living thing only if the outer, covering layer is broken—e.g. through a cut or scratch.

*Microscopic life*

The children should know that in fresh- and salt-water there are millions of plants and animals which are too small to be seen without a microscope. They form the food of vast numbers of larger water-animals. Some diseases are caused by microscopic animals. Many other diseases are caused by *bacteria.*

## C. BACTERIA

Harmful bacteria often get so much emphasis that children grow up with the impression that all bacteria are dangerous 'germs'. This is a great mistake, and it is advisable to consider the useful bacteria first, especially as these link up with the useful work done by moulds.

### (3). *Decay*

Discuss what would happen if dead plants and animals did not decay. Thus show the great importance of the moulds, fungi, and bacteria which cause decay and so help to make the soil fertile. Do not lose the opportunity of showing the children that there is nothing useless or 'impure' in Nature. Excrement and rotting carcasses are considered to be dirty and unclean to Man and, if not disposed of, may bring disease, but in Nature they are important and useful. Nothing is wasted, and the useful bacteria and moulds are always at work changing such dead things into materials which plants can use as food. Moulds and bacteria are living things, so they must have water, air and warmth. In VERY cold places there is no decay, because it is too cold for bacteria to be active. In very dry places decay is slow, but in hot, damp countries decay takes place rapidly because conditions are favourable to bacteria.

*Practical work*

Make a *compost-heap* or *compost-pit*. (Quite good compost can be made from plant remains, omitting the dung.[1])

Why must the heap be watered if the weather is dry?

### (4) *Fertility of the soil*

There are other useful bacteria besides those which cause decay. Some of these live in little swellings on the roots of plants such as peas and beans, and they help to make the soil fertile, that is, good for plant growth. Discuss what the children already know about how plants use food material from the soil. If a woman keeps on taking grain from her store for cooking, in time the store will be empty. So if we allow crops on our land to keep on using food material from the soil we shall find that the materials for plant food gradually get less; as a result we get poor crops, and we say that the soil has become poor. But in the forest or jungle the soil does not become poor. Why not? Because in Nature crops are not cut and harvested; ground is not cleared of weeds and fallen leaves; plants fall down and rot where they have grown, and the bacteria of decay change them again into food material. Nature puts back in the soil what she has taken out; we have to do the same if we want good crops.

All this must be closely linked with the work in the school-garden and also with agriculture as practised by the local community. Discuss different ways of manuring, and as far as possible, put them into practice in the garden. Include green manure. Dig up any plant of the bean family, e.g. cow-pea, and show the swellings on the roots. If shifting cultivation is practised in the district, discuss its disadvantages.

Diseases caused by bacteria are discussed in Volume III of this series, on the Teaching of Health Science.

SCHEME II (*mainly for rural areas*)

As this scheme must be very closely related to local condi-

[1] See *Water and the Land*, p. 27 (book list, p. 228).

tions, it is only possible here to give a general outline of what work to include. It is important, in rural areas, to give more time to outdoor work on the farm or in the garden. The observant teacher can give much valuable incidental teaching, which can take the place of more formal teaching in the classroom.

A study of :—

(*a*) *Local crop plants.* External appearances; methods of propagation. Preparation of soil; planting; cultivation ; harvesting. Subsequent preparation and use of crop.

Enemies of the crop and how to combat them.

(*b*) *Local farm and domestic animals.* External features. Characteristics of good breeds. Care of the animals. Common enemies and diseases of the animals.

In seaside communities where fishing is the main industry:—

*The chief food fishes*, their external appearance; their food and habits. Methods of catching them. Enemies of the fish—e.g. Sharks.

(*c*) *Moulds, bacteria and decay*, as for Scheme I.

(*d*) *Flowers, pollination* and *fertilization*, as for Scheme I; to be discussed as far as possible in connexion with the study of crop plants.

### HEALTH TEACHING

Most of the work for this year is dealt with in other sections of this chapter. Thus the teaching and activities which centre round 'Our Water Supply' are dealt with under 'Earth and Universe' (see p. 136); the teaching about infectious diseases will be included under 'Living Things' when the children learn about Bacteria.

#### *The water supply* (*outline*)

Link the lessons with those on the circulation of water in nature.

*Sources of water supply:* Water-holes, ponds, streams, rivers, springs, wells.

Diseases contracted by drinking unclean water: e.g. cholera, typhoid, dysentery, Guinea worm.

Diseases contracted by bathing in infected ponds: e.g. Bilharzia disease.

*Purification of water by:* (*a*) Filtering, (*b*) Boiling.

*Keeping our water supply clean by:* Covering wells and springs; keeping the ground around wells and springs clean; using clean vessels for water storage and for drinking.

### *Infectious diseases*

Link the teaching with that on Bacteria.

*Diseases spread by the breath of infected people*, e.g. sore throats, colds, influenza, chickenpox, measles, whooping cough, small-pox. (Mention only those which are familiar to the children.) Avoidance of overcrowding, spitting and dust. Necessity for good ventilation, especially at night. The importance of covering the nose and mouth when sneezing and coughing.

### *First aid*

Disinfectants and antiseptics: connect with Bacteria. Treatment of cuts and sores.

## EARTH AND UNIVERSE

In previous years the children have acquired elementary ideas about such everyday things as wind, clouds, rain, air and water. They will have seen experiments which show that air is something real; that it occupies space and is needed for burning. They know that when water dries it goes into the air in the form of water-vapour and that water-vapour can be changed back into liquid water. Revise these ideas and do any experiments omitted before. Now the class will be ready to learn more about these two necessities of life—air and water—and will connect what they learn with their weather observations and with the uses of water in the community.

*Main ideas to be brought out*

(1) Some substances are heavier than others.
(2) *Air* presses in all directions; consequently it flows into every open space and crack.
(3) Hot air is 'lighter' than cooler air.
(4) Heat makes the air move, because warm air is pushed up by cooler air. Thus *winds* are caused.
(5) *Water* can be solid, liquid or gas.
(6) The water on the earth is constantly changing from one form to another.
(7) Our water-supply should be made and kept as clean and pure as possible.
(8) Many diseases result from drinking unclean water and from bathing in infected ponds.
(9) A thermometer is used for measuring how hot things are.
(10) Evaporation has a cooling effect.

### (*1*). *The weights of substances*

*Practical work*

*a.* Weight various objects with the spring balance and record their weight.

*b.* Weigh the objects used in the last experiment using either a home-made beam-balance, or scales such as are used in local markets. If the children have not had practice in weighing (e.g. during their arithmetic lessons) this will have to be done now. Write down the results and see if they are the same as those measured with the spring balance. Test some of the weights used, by hanging each from the spring balance. This will bring out the fact that when using scales we *balance* the things to be weighed against an object whose weight we know.

*c.* Find what weight of water a cigarette tin will hold, by weighing the tin, first empty and then filled to a mark with water. (Use the spring balance; make three holes at equal distances from each other round the top of the tin and pass threads

through them. Repeat the experiment using some other liquid such as oil or milk.

If the objects for the above experiments are well chosen and if enough suitable substances are tested, it should be possible at the end to reach these conclusions:—

1. The weight of an object depends on:
   (*a*) Its size.
   (*b*) The substance of which it is composed.
2. Some substances are heavier (denser) than others.

### (2). *Air pressure*

The fact that still air presses in all directions is always difficult for children to understand. It is one of the many cases where our senses mislead us; we do not *feel* the air unless it is moving, so how can it be pressing on us?[1]

*Practical work*

*a.* Take a matchbox cover and a small sheet of paper. Suck in the air as shown in Figure 30. As long as you continue to suck, the paper will be held in position by the pressure of the air outside. The moment you stop sucking, air enters through your nose, and so the pressure on each side of the paper becomes the same and its weight causes it to fall.

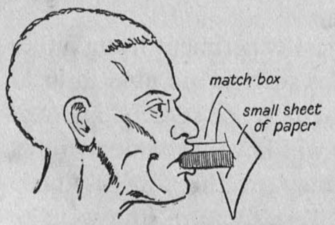



FIGURE 30.—A simple demonstration of air pressure

By moving your head and repeating the above experiment in different positions, you can show that the air presses in all directions: upwards, sideways and downwards. If the paper is

[1] Teachers will find helpful illustrations in *In Search of Science*, Book I, Chap. X, and in *Weather* in the 'Science at Work' series. They are also advised to read Chap. II of *The Air around Us* by W. E. Flood. (See book list, p. 228).

thin it will be 'sucked in' just as though someone were pushing it from outside; it is in fact being pushed by the pressure of air. (Of course many other things will serve just as well as a matchbox cover.)

*b.* Take a small lamp chimney or a funnel which has a perfectly smooth, level top. Cover it with a piece of thin rubber sheet; an old toy-balloon is best, but bicycle-tubing will do. Let it be loose in the middle (not stretched), but make the sides airtight with a strong rubber band or adhesive tape. Suck at the other end of the funnel; the rubber sheet appears to be pushed inwards. Now take a piece of glass which has been well greased and press the greased side firmly over the rubber sheet. Whilst still pressing, suck again. Now the rubber does not move; although you have sucked air out of the funnel as before. This is because there is no air pressure on the rubber from outside.

*Note:* It is simpler to do this experiment with a teapot, as the spout is convenient to suck; on the other hand the class cannot so easily see what is happening.

*c.* Before the lesson, tell the pupils to see how many of them can do this at home: to try to suck the air from a small bottle. Ask those who did it if they noticed anything unusual. Can they explain why the tongue seemed to be 'sucked' into the bottle?

*d. Suckers.* Cut a round piece of thick leather or of rubber. Make a small hole in the centre and pass a string through it, knotting the string at the lower end. If leather is used the sucker must now be very thoroughly soaked in water; a rubber sucker only needs to be wetted on its surface. Press the sucker firmly on to any *smooth* surface which will give an airtight joint. Let some children feel how hard they have to pull before the sucker comes off. The best way is for each child to make his own sucker. Try lifting smooth stones with suckers.

Attach a spring balance to the string of a sucker. What is the pull in pounds which is needed to make the sucker come away from the surface?

Use the sucker to hang a stone from the underside of a table. Emphasize that in all cases we pull against the pressure of the air when we pull the string; when we press the sucker against the surface, we press out most of the air beneath it and so there is no pressure from inside to balance the outside air pressure.

Some animals can run over glass and other smooth surfaces by means of suckers on their feet: e.g. a housefly, a gecko. Children living near the sea may know the cuttle-fish, which has strong suckers on its 'arms', by means of which it holds on to its prey.

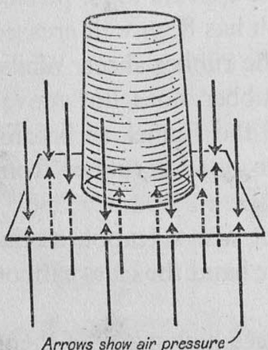



FIGURE 31.—Air pressure holds the card in position

*e.* Choose a bottle or glass with a smooth, level top. Fill it with water. Press a thin piece of cardboard over the top and quickly invert the glass. Upward pressure of the air holds the card in position (Figure 31).

*f.* Suck up some coloured water in a glass tube. Quickly close the top end with your finger and lift the tube out of the water. What holds the water in the tube? What is there in the tube above the water? Why does the water flow out as soon as you remove your finger?

*g.* Discuss why it is necessary to make two holes in a tin of condensed milk, or kerosene, in order to pour out the liquid easily.

*h.* Take a rubber bulb and tube. Show its use. With the aid of blackboard diagrams discuss exactly how it works.

*i.* Take a *fountain pen* (of the 'rubber-bag' type) to pieces and show how it works. If the lever is raised with the nib under water, the escaping air bubbles are seen.

### *(3) and (4). Hot and cold air*

Some elementary books state that warm air rises and cold air flows in to take its place. This is rather misleading. The air

does not rise *because* it is warm: it is more correct to say that the warm air is pushed up by the heavier cooler air.

Discuss everyday events and common experiences which show that hot air rises—e.g. smoke from an open fire on a still day. Why does it rise? If there is smoke in a closed room, does it rise? Smoke is made up of small, solid particles which fall if the air is still; they are carried upwards with the upward current of hot air over a fire. When cooking we place pans *over* the fire where they get most heat.

*Practical work*

*a.* Put your hand at the side of a candle flame and then above it; where does it feel hotter?

*b.* Use a *pinwheel* to show that hot air rises. Pinwheels may be cut in various ways; the first one described here gives very good results and is useful for demonstration by the teacher.

On stiff paper draw a circle 2 inches across. Make eight cuts as shown in Figure 32. Mark the exact centre. Bend a part of

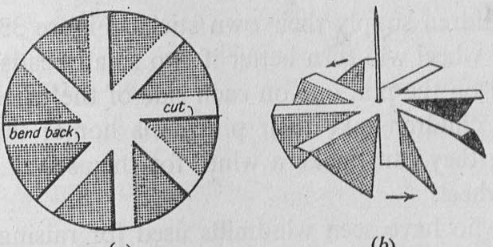



FIGURE 32.—A pinwheel made of paper

(*a*) Cut along the heavy lines.
(*b*) Bend back along the dotted lines.

each section downwards as shown in the diagrams. Pass a pin through the centre mark and see that the wheel can turn freely round the pin while supported by the pinhead. Hold the wheel above a kerosene lamp or candle flame. The wheel spins rapidly; move it away and the spinning stops. What makes it turn? To answer this question, hold the wheel sideways, pinhead towards

you with your finger and thumb just behind the wheel. Blow straight at the centre; again the wheel turns. Now raise the wheel above your head and blow upwards at it. You have thus shown that the wheel turns when wind (a current of air) blows on it from what we may call the under side. Wind is moving air, hence air must be moving upwards from the flame.

*c. Making pinwheels.* Every child should make his own. Requirements: stiff paper,[1] pins and, if possible small glass

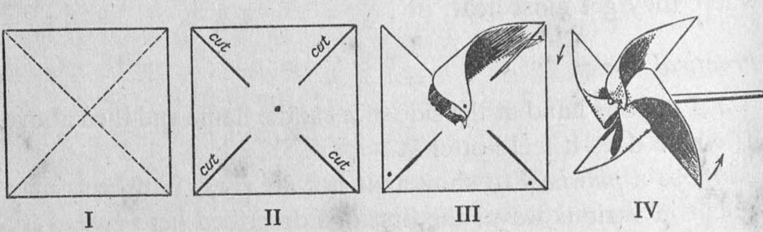



FIGURE 33.—Another pinwheel

I. Take a square piece of paper and fold it to make the creases shown by the dotted lines.
II. Cut along the thick lines.
III. Turn the corners marked *x* to the middle.
IV. Put a pin through the middle and pin the wheel to a stick.

beads. Children supply their own sticks. Figure 33 shows the steps. The wheel will turn better if two small beads or buttons are placed on the pin, one on each side of the wheel.

Let the children take their pinwheels home; they will discover that they can 'make a wind' for themselves by running with the wheel.

Those who have seen windmills used for raising water will now understand why the 'sails' turn.

### (5) *and* (6). *The changes of state in water*

The children have done experiments during the previous year to show that water can be changed from one state to another. Revise what they did, introducing now the words solid, liquid and gas.

Lead on to a summary of the Water Cycle.

[1] Newspaper will do if nothing else is available.

### *The Water Cycle in Nature*

There are three main questions to be answered: What happens to all the water that falls on the earth? What happens to the water that sinks into the soil? How does water return to the air?

The children may have wondered, when they see water sinking into the ground, whether it comes out again or not. If so, does it all come out, or does some go deeper and deeper so that it never gets to the surface again? If this latter were to happen the amount of water in the world would constantly become less. Actually it does not happen because there are some rocks and soils which do not let the water pass through them; thus we get springs. The same water keeps on circulating. Make a simple diagram of the Water Cycle for the children to copy.

*Practical work*

*a. Comparison of properties of sand and clay (and garden soil).* Take three similar small tins (e.g. cigarette tins) and make twelve small holes in the bottom of each tin, using a small nail and a hammer. Also make three holes spaced equally around the upper part of the sides and hang up the tins side by side, with string. Half-fill one tin with *dry sand*, put the same quantity of *dry powdered clay* in another, and the same quantity of *dry garden soil* (loam) in the third. Place three similar jars or tins beneath the hanging tins, measure out three equal quantities of water (not more than half a cigarette-tinful) and get three children to pour the water, at the same time, into the hanging tins, counting, 'And one, and two, and three, etc., —' until the first drop of water falls from each hanging tin. Record on the blackboard:—

Time taken for water to pass through *sand* = count of......
" " " " " " " *clay* = " "......
" " " " " " " *loam* = " "......

At the end of the lesson, measure the volume of water which

has drained through each tin. Most water runs through the .........., i.e. .......... retains little water and drains quickly. Least water runs through the .........., i.e. .......... retains much water and drains slowly. The .......... was intermediate between .......... and ..........

*Alternative method.* If you have three glass or tin funnels and half-a-dozen test-tubes, you can do the above experiment more neatly. *Lightly* plug the bottom of the funnel-cone with a bit of twisted cloth, or cotton-wool, and place equal quantities of dry sand, clay and good garden soil in the funnels (which should not be more than half full). Stand each funnel in an empty test-tube: fill three more test-tubes brim-full of water and get three children to pour these equal quantities of water into the three funnels, all pouring at the same time on your signal. Then proceed as above, finally comparing the amounts of drainage water by holding a ruler alongside each test-tube, in turn.

*Note:* The following arrangement provides a very simple form of this experiment:—

Use three tins with perforated bottoms. Pour water in until it just begins to drip out below, and compare the amounts of water held.

Then hang the tins by string and pour in more water—catch the run-through and compare.

This may be substituted for the usual lamp-chimney version (see below), though it has the disadvantage that the tin is not transparent.

*A second alternative.* Take two similar lamp chimneys; tie coarse cloth or several layers of mosquito netting over the bottom of each of them. Put dry sand into one and dry powdered clay into the other, filling them to the same height. Put two funnels into two glass jars (or tins) and ask children to hold the chimneys over the funnels (or clamp them in position if you have clamps). Pour the same measured quantity of water into

each of the two chimneys. Compare the heights of the water in the jars beneath; measure the amount of water which has run through in each case by pouring it from the jar back into the measuring-glass (Figure 34).

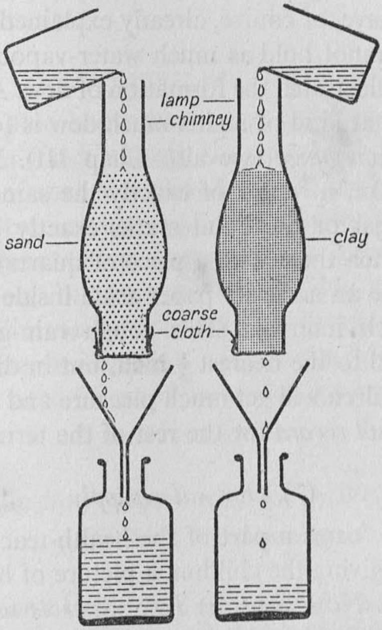



FIGURE 34.—Comparison of sand and clay

*b.* If there is a standpipe in the school grounds you can illustrate how a spring is formed. Put a board underneath the tap; put a thick layer of clay all over the board and then put a large heap of sand on top of the clay. Now allow the water to drip on to the sand. Soon you should have a model spring.

*c.* To show condensation, breathe on a slate, a piece of glass or a mirror. Boil some water in a tin, and hold a tin or a slate over it. Let the children explain exactly how the water gets from the tin on to the slate.

*d. Dew.* It is not easy to show condensation of water from the

atmosphere in hot countries, owing to the difficulty of obtaining anything that is cold enough. If you can obtain a little ice or ice-water place it in a clear glass or a tin with a shiny surface. Notice the drops of water, which are condensed on the *outside*, from the surrounding air, as it is cooled by contact with the cold surface. (You have, of course, already explained to the children that cool air cannot hold as much water-vapour as warm air.) You have just illustrated the formation of dew. Ask the children to notice on what kind of nights much dew is formed.

*e. Make a rain-gauge* (see also Chap III). Make, or get a tinsmith to make, a funnel of exactly the same diameter as a wide-mouthed jar or tin. Paint marks exactly $\frac{1}{2}$ inch apart up the jar (or scratch them with a piece of quartz). In the case of a tin, first paste an accurate paper scale inside and then paint marks at $\frac{1}{2}$-inch intervals. This rough rain-gauge will only measure rainfall to the nearest $\frac{1}{2}$ inch, but in districts of heavy rainfall the children will get much pleasure and interest from it.

Keep a *rainfall record* for the rest of the term.

### (7). *Our water-supply*

This topic also forms a part of the health-teaching. You have led up to it by giving the children a picture of how water circulates in nature. Now consider *how water is used in the community*. It is used for drinking, cooking, bathing, washing kitchen utensils and clothes; for our crops; for our farm animals. These are uses common to all communities; dwellers in each particular village or town will be able to add others. Discuss in general terms *how and where we get our water*.

#### *Practical work*

Make a frieze[1] for the classroom showing how we get our water and how we use it. Different children make pictures of such activities as drinking, cooking, washing, drawing water, carrying water, taking cattle to a drinking-place. If modelling is

[1] A frieze is a narrow picture running along one wall or round a room.

preferred, the class can make a village scene depicting these activities.

Discuss the source or sources from which your own community gets water. Compare these with other possible sources, e.g. water-holes, ponds, streams, rivers, springs, wells, piped water from reservoirs.

### (*8*). *Dirty water and clean water*

The children should know that certain illnesses can result from drinking impure water, though they need not know details of the symptoms of such diseases. Typhoid and dysentery occur throughout the tropics; cholera in some countries; guinea-worm infection in others. Other illnesses result from bathing in infected ponds—e.g. Bilharzia disease. Having learnt something of how these diseases are caused the children should be impressed with the fundamental importance of a clean water-supply and the need for purifying water coming from doubtful sources.

*Filtering*. Explain how water is cleaned by filtering.

*Practical work*

*a*. Shake up some mud and water in a large glass jar. The mud slowly settles to the bottom, but the water is still not perfectly clear. Stir it and watch the result; the same thing happens every time that a person or animal walks into a pond.

*b*. Filtering through paper. Use a funnel and a round piece of blotting-paper folded as in Figure 15. Pour muddy water on to the filter.

*c*. If you have, or can get, a household filter, show it to the children and explain its use. Emphasize the necessity of keeping the 'candle' clean.

*d*. Explain how water is filtered at a large waterworks. Make a model filter-bed, using a big flower-pot or a large tin with a hole in the bottom. Cover the bottom hole with stones, then

put in gravel and then sand. Lay a piece of glass on top of the sand, in the middle, and pour the water on to the glass so as not to disturb the sand (Figure 35). Support the 'filter' on two bricks or boxes over a glass jar. First pour on clean water to wash the filter and when this comes through quite clear, pour on muddy water. Compare the water which comes through with that which has not been filtered.

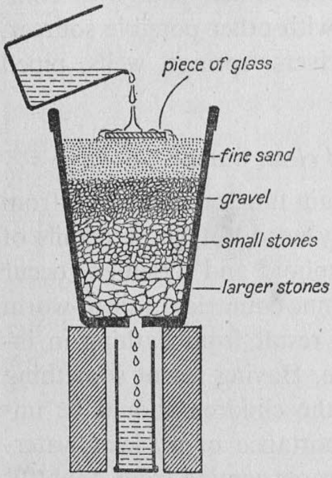


FIGURE 35.—A model filter-bed

*Boiling*. Explain that bacteria and some other living things which cause diseases are so small that they pass through a coarse filter. Drinking-water should always be boiled unless it comes directly through pipes from a good waterworks. Boiling kills bacteria. At waterworks the bacteria are destroyed by putting into the water certain substances which kill bacteria but are harmless to man.

*Clean drinking water*. Emphasize that it is no use having a clean source of water if we then collect and store our drinking-water in dirty water-pots, or drink from unclean vessels.

*Keeping the community water-supply clean*. Explain the necessity for covering wells and springs, and how the ground around them should be kept clean.

(9). *The thermometer*

The children will learn in the next school-year how the thermometer works. In the meantime they should be introduced to it simply as a means of measuring 'hotness', or temperature, and should learn how to read it.

*Practical work*

*a*. Draw on the blackboard a large diagram of a thermometer. We often want to know exactly *how hot* something is; then we use a thermometer. We speak of 'degrees' of 'hotness': when we measure how hot something is, we say 'its temperature is so many degrees'. Collect the class around you in groups and let them all see the liquid which fills the bulb and reaches some way up the tube. Explain how to read the thermometer. Warm the bulb with your hand and let them see the liquid rise. Thus show that the liquid rises as it gets hotter and expands, but sinks again as it cools and contracts.

Ask a child to come and read the temperature of some water in a tin. Now gently heat the water; let the child call out the numbers as the temperature rises. Leave the thermometer in this water and read it again at the end of the lesson.

*b*. If the school has a thermometer on the wall of a room or verandah, start a daily record of temperature, to be kept by a different pair of children each week. See that they read it at the same time every day.

## (*10*). *Evaporation causes cooling*

We always associate water with coolness. There are many reasons why a large body of water always feels cooler than the surrounding air, but small puddles become quite hot when the sun shines on them. The cool feeling that we associate with water is mainly due to the fact that when a liquid evaporates it must take heat from *somewhere*: from itself and from whatever is touching it. Thus evaporation causes cooling.

This fact has important practical consequences. When sweat evaporates from the skin it helps to cool our bodies. Patients with high fever are sometimes sponged with warm water; the rapid evaporation cools them. If wet clothes are worn, much water will evaporate from near the skin, consequently taking heat from the body, and we may 'take a chill'. Why is it especi-

ally dangerous to sit in wet clothes if a wind is blowing? Plants lose water from their leaves, and this evaporation cools them. We can keep food and drink cool in water-coolers and damp cloths.

*Practical work*

*a.* Find the direction of the wind on a still day. See Chap IV, p. 71.

*b.* Dip a finger into petrol and then hold it in the air. Why does it feel cold?

*c.* Pour some water into a jar and pour the remainder of the water into a porous earthenware water-cooler. Take the temperature of the water in both vessels. Set them side by side in a breezy place. Take the temperatures at intervals during the day.

*d.* Take the temperature of some water. Dip a small piece of cloth into the water and wrap it round the bulb of the thermometer. Can you record a difference in temperature? (If your district is very damp, evaporation will be very slow.) Notice the difference when you fan the cloth.

*e.* Show how to keep food cool by wrapping the container in a cloth which dips into water.

## MATTER AND ENERGY

Children love to watch a craftsman at work: the village blacksmith, weaver or potter will usually have a group of spectators; in towns children gather to watch men at work building, attending to faults in the electricity- or water-supply, or repairing a broken-down lorry. All these people are using tools or machines to help the power of their muscles and the skill of their hands and brains. In the case of machines the children begin to wonder 'how it works'.

Most children share in the work of the home and so learn to use simple tools. A few very elementary lessons at this stage will prepare the pupils for more formal work later. The title for this year's subject might be:

### *Ways of making work easier*

*Main ideas to be brought out*

(1) People must work hard in order to live. Man has many ways of making work easier.
(2) Man uses the strength of animals to do work for him.
(3) Man uses tools and machines.
(4) Wheels and springs help to make work easier.
(5) Levers help to make work easier.
(6) The power of wind can help us to do work.
(7) The power of water can help us to do work.
(8) Engines help us to do work. They may be driven by coal, petrol, oil or electricity.

#### *(1), (2) and (3). Easier work: the use of wedges, wheels, levers*

*Practical work*

*a.* Have a talk about *Work*; get children to describe how various kinds of work are done by different people in the home and village. Make a list of the *tools* used at home and in the fields, e.g. knife, spoon, sweeping-brush, needles, scissors, cutlass, axe, pestle and mortar (or pounding-stone), hoe, plough, cart and so on. Picture yourself trying to prepare food with no tools to help you. Give a child a piece of wood with some nails in it, not too firmly fixed. Ask him to remove them. With the fingers it is difficult; how could he do it more easily? Give another child a broken pencil; he is unable to do the simple work of sharpening a pencil unless he has some tool. Supply some sharp stones. Try to cut fruits and to sharpen pencils with them.

Animals do not use tools. Men cannot do all they wish by using only their hands and teeth. Very long ago men learnt to sharpen stones; they used them for cutting things. Later they found out how to make iron and so they could make better knives. The two most important first uses of tools are:

1. For cutting.
2. For moving things.

*b. Cutting*. Split a piece of wood using a wedge and hammer. For a small soft bit of wood a knife will serve as the wedge. Any tool meant for cutting or piercing has a narrow edge or point and gets gradually wider; it acts as a wedge. Draw the shape (Figure 36(*a*)), and make a list of wedge tools, including nails and needles.

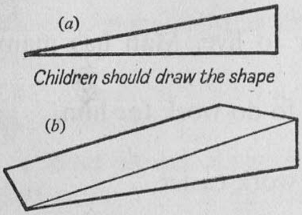



FIGURE 36.—A wedge

*c. Moving things*. The first of three ways of moving heavy things easily:—

*Rolling up a slope* (inclined plane).

Get a log of wood too heavy for the children to lift. Ask them to suggest the best way to get it up on to the verandah. Supply a plank and let them roll it up. Have they seen heavy objects loaded on to lorries in this way?

### (4). *The use of wheels*

Wheels give us a second way of moving heavy things easily.

*Practical work*

*a*. Get a heavy box with stones inside. Ask some children to pull this up the sloping plank. This is difficult. How could the heavy box be made to move easily? Discuss the different ways in which wheels help us when shifting heavy loads. Examine any devices or machines which move on wheels, and look at the axles on which the wheels turn.

*b*. If possible try to arrange that, in their Handwork lessons, the children make some form of toy which moves on wheels, using either wood or cardboard.

The chief value of the work, whether it is done individually or on a large scale as a class project, lies in letting the children discuss how to fit the wheels.

*c.* Visit any local craftsmen who use wheels, e.g. the potter. Try to find out exactly how the wheel is made to turn.

*d.* Make a list of machines you have seen in which wheels are used.

*e.* If your school has a flagstaff with a pulley for hoisting the flag, notice how it works.

*f.* Show separate *gear wheels*. Look inside an old clock or anything which has a clockwork mechanism, e.g. a musical box or toy clockwork car. Show that gears are wheels with teeth. One gear wheel makes another gear wheel turn in the opposite direction. A bigger gear wheel makes a smaller one turn faster and vice versa.

*g.* Look at the gear wheels of a *bicycle*. The chain makes them turn in the same direction. Which wheel turns the faster?

*h.* Examine the *spring* of an old clock or gramophone. Be careful not to release a wound-up spring suddenly, as great force is exerted and somebody may be injured. Explain how we wind the spring, and how it moves a wheel as it slowly uncoils.

### (5). *Levers*

These provide us with a third method of moving heavy objects. No mechanical explanations are to be given nor calculations made at this stage. If a good plank can be obtained, it is much better to have the demonstration out-of-doors.

*Practical work*

*a.* Lift a heavy box using the plank as a lever, and a stone, or triangular block of wood, as the pivot. Show that the nearer the weight is to the pivot, the easier it is to lift.

*b.* Place the plank over a log and make a see-saw. Let the children balance each other. Find out how one child can balance two others by varying their positions on the plank.

*c.* In addition to, or instead of, the above activities, have small-scale classroom demonstrations, using a ruler or, preferably, a stronger piece of wood. Hang weights from it. Move

the weight away from the pivot until the box is raised; see Figure 37. Use scales afterwards to find the weight of the box.

In some countries children will be familiar with a method of

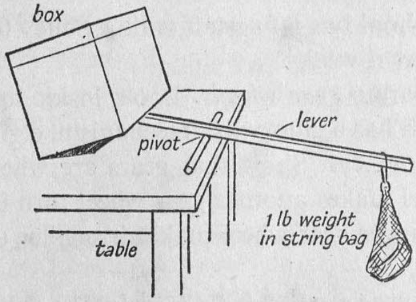



FIGURE 37.—A simple lever. (It is best to use a small rod for the pivot.)

lifting water which employs a lever. *Oars* which rest in row-locks plainly act as levers. It is less easy to appreciate that a canoe paddle is also a lever.

*(6), (7), and (8). Sources of power*

Show that in machines such as the water-lifting machine (*shadouf*), hand-loom, bicycle and sewing-machine, men must do the work; the man uses his muscles, but the machine helps him to do the work more easily and more conveniently. There are other machines which appear to 'work by themselves'; a man does not become tired after driving a car; his own muscular strength is not used, and a small, weak man can make the car go just as fast as a big, strong man can. Long ago, before men had learnt to make machines, they were afraid of the very strong forces which they found in the world. Gradually men learnt how to use natural sources of power, such as wind and running water, to help them in their work.

*The power of moving things.* Anything which is moving has strength or force: e.g. throwing balls or stones to knock things down; rolling things downhill. What happens when somebody

who is running knocks against you? When any moving object hits you, the faster it is moving the more it hurts you, for it has greater force. Get children to give examples, or tell stories, of the power of wind and of moving water.

Familiar examples of the use of *wind-power* and *water-power*:—sailing-boats, windmills; travelling downstream without paddling, floating logs downstream; waterwheels; waterfalls which are used to turn machines at power-stations where electricity is made.

*Practical work*

*a*. Make a *cornstalk waterwheel*. You need only a cornstalk, two pins and a piece of wire. Cut thin strips of the outer covering from the cornstalk; insert them around the centre of a 4-inch length of the pith in a manner similar to the spokes of a wheel. Insert pins in the ends of the pith to serve as an axle. Fix wires to the pins and support the wheel over a small stream of water. If you have no stream nearby, but have a standpipe, make a stream by attaching rubber tubing to the tap.

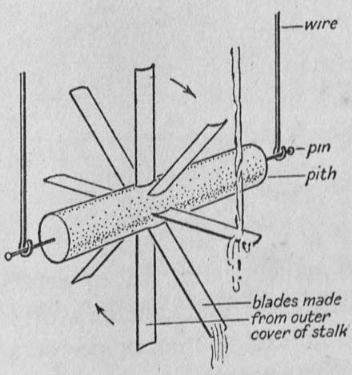



FIGURE 38.—A cornstalk waterwheel

*b*. Pinwheels illustrate the effect of wind-power. The pinwheel is a toy windmill. If there is a windmill used for raising water near you, make a drawing of it.

### *Engines*

*N.B.*—Do not attempt any *study* at this stage of how heat-engines work. Of course you must always try to answer, as simply as possible, any questions the children ask; when their interest is roused you must try to keep it.

### *Practical work*

*a.* Make a collection of pictures of machines and engines. Say what is used to provide the force in each case.

*b.* Use the cornstalk wheel (Figure 38) to show that steam exerts force and can be used to turn a wheel. Boil a kettle and hold the wheel just in front of, and above, the spout.

*c. Loosely* cork the spout of a kettle which contains a little water. Bring to the boil. If the lid fits tightly the force of the steam will blow out the cork. Sometimes it is the lid that is lifted.

CHAPTER VIII

# Teaching Science in the Fifth Year

## LIVING THINGS

During this school year the pupils learn something of how their bodies work. We are able to keep alive and to enjoy health because very complicated processes are going on in our bodies all the time. Our hearts beat regularly, sending the blood round our bodies; we breathe, eat our food, digest it, get rid of waste; we run, jump, learn how to make things with our hands; we enjoy things that we see, hear, smell, taste and touch. All this is possible because our bodies are in good working order, or, as we say, in good health. The pupils have already learnt certain health rules. Now they can understand some of the *reasons* for these rules.

This is *not* to be a first course in anatomy. Children only need to know about the parts of their body in briefest outline. So give a very clear, simple account of how the body *works* and make it your aim to relate the teaching throughout to the Health Teaching.

Include some lessons on 'How Plants Live'. These lessons will emphasize that plants are also living things; they will show too the very important part that green plants play in the world.

IMPORTANT: *The work on 'Air' and 'Burning' forms an introduction to this section and* must *be taken first* (see p. 174).

*Main ideas to be brought out*

(1) Animals and plants are alive and they all:

(*a*) need food, water and air;

(*b*) use their food for growth and storage, and use part of it to supply energy and warmth;

(*c*) grow, reproduce themselves and die.

(2) Green plants differ from animals in the way they feed.

(3) Animals digest their food before they can make use of it. They use plants or other animals as food.

(4) The blood carries digested food round the body.

(5) Green plants build up their own food in the leaves from simple non-living substances, which they obtain from the air and soil.

(6) If there were no green plants, men and all other animals would soon die because:—

(i) All the food in the world would be used up, as only green plants can make food from non-living matter.

(ii) The amount of oxygen in the air would diminish and the amount of carbon dioxide would increase until the air was no longer fit for animals to breathe.

(7) Breathing means taking in oxygen and getting rid of carbon dioxide. Both animals and plants breathe.

(8) The blood carries oxygen from the lungs to the body and carbon dioxide from the body to the lungs.

(9) Waste products (substances that the body does not need) are removed in the urine and in the air breathed out.

(10) Waste products from plants are carbon dioxide and oxygen (and this oxygen keeps the air 'fresh' for animals to breathe).

(11) Our bodies have a strong framework of bones most of which are jointed together. Muscles bring about movements; they are attached to the jointed bones by tendons.

(12) We have a brain and nerves. Nerves carry messages to the brain from the eyes, ears and all the other parts of the body. Nerves carry messages from the brain to the muscles and cause them to bring about movements.

(13) Some animals are parasites; they make use of food which has been digested by other animals. Some parasites cause diseases.

Aim at teaching the *basic* ideas given above; then the children will not be confused by too many new terms.

## (3). *Digestion*

First give a general idea of the structure of the body: (*a*) the chest-cavity, containing heart and lungs, and (*b*) the belly-cavity, containing other internal organs. Regard the alimentary canal as a tube, called the food-tube, which extends from mouth to anus, the stomach being simply a wide portion of the tube. Teach only the names shown in Figure 39.

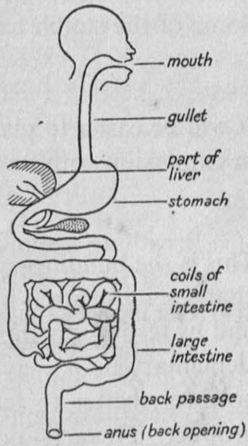



FIGURE 39.—A simple diagram of the 'Food-tube'

Use the knowledge of solutions gained in the Fourth Year to explain that our food must be made soluble so that it can pass through the walls of the intestine and enter the blood. Explain that there are various digestive juices, which contain substances that act on our food and change it. If the school follows the scheme of work suggested in this book, the children will not learn about the three classes of foodstuffs until next year, but they can get a general idea of the digestive system without reference to proteins, fats and carbohydrates. Saliva can be discussed and its action demonstrated; the second digestive juice is made in the stomach; it helps especially in the digestion of meat. Other digestive juices are mixed with the food after it leaves the stomach. No further details about digestive processes are necessary at this stage: the essential point is to understand that the food is broken down into simpler substances and made soluble. The dissolved

food passes through the walls of the small intestine into the blood, which carries it to all parts of the body. The food that cannot be digested is prepared for leaving the body, and is expelled from time to time as faeces.

*Practical work*

*a.* Take two cigarette-tins of water. Put a spoonful of sugar into one and a spoonful of starch into the other. Stir, then filter. Thus show that sugar is soluble in water, starch is not.

*b.* Chew a piece of starchy food, e.g. bread, in the mouth for some time without swallowing; notice the slightly sweet taste. Some of the starch has been changed into sugar by the saliva.

### (*4*). *Blood circulation*

It will be easier to plan a lesson on the circulation of the blood in connexion with breathing.

### (*5*) *and* (*6*). *Photosynthesis*

This is the building-up of sugar in green leaves; this sugar soon changes into starch in the leaves of many plants. It is easy to find by testing whether starch is present or not, and hence many elementary books say that starch is made in green leaves. It is, however, better to teach from the first that sugar is the first product. There is no need to teach the children the word 'photosynthesis' at this stage. Tell them they are going to learn 'how green plants get their food'.

*Introduction.* (*a*) Remind the class that water enters the roots and passes up the stems to the leaf veins; from there it reaches every part of the leaf.

(*b*) Explain that there are openings in the leaf skin through which gases can pass in and out.

(*c*) Show that all green parts of plants contain a colouring matter named leaf-green (chlorophyll).

Now do the practical work on pp. 152–4.

When explaining how the plant makes its food, avoid analogies with 'cooking', as this comparison is most misleading and does not convey the idea of building up food from simpler substances. It is useful to compare the leaf to a workshop where furniture is made. The workshop is thought of as having many windows and a number of pipes supplying water. If we are to make furniture we need *materials* (wood, nails, screws, etc.), which must be brought into the workshop. But these will be useless without tools with which to work on them. Raw materials and tools can lie idle; if they are to be useful, work must be done, and so *energy* is needed. (We say that the carpenter is tired after his work; he has used up his energy.) Finally, the finished furniture piles up in the workshop; it will be necessary to have it regularly removed to places where it is needed, otherwise the workshop will become overcrowded and work will have to stop. Now work out the comparison with the plant, building up the following table on the blackboard.

| | | |
|---|---|---|
| LEAVES | correspond to | A WORKSHOP |
| WATER AND CARBON DIOXIDE | correspond to | MATERIALS SUCH AS WOOD AND NAILS |
| LEAF-GREEN | corresponds to | THE TOOLS |
| SUNLIGHT | corresponds to | THE CARPENTER'S ENERGY |
| OXYGEN | corresponds to | WOOD SHAVINGS AND OTHER WASTE |
| SUGAR | corresponds to | FURNITURE |

Finally arrive at the conclusion:—

The leaves are plant-workshops, where the green colouring matter makes use of energy from the sunshine to build up sugar from carbon dioxide and water. The carbon dioxide comes from the air, and the water from the soil. Thus plants build up their food from simple substances which are useless as food to animals. This wonderful process is the starting-point of all the food and life in the world.

The soil-water has mineral salts from the soil dissolved in it. These are taken in through the roots and used in the leaves to make other foods for the plant.

*Practical work*

*a.* Show that there are tiny holes in the leaf skin. Choose a kind of leaf that is fairly large and firm. Pick fresh ones and immerse them in a glass jar containing hot water. Bubbles are seen escaping. What drives the air out of the leaf?—The heat causes it to expand. (Indian Almond (*Terminalia catappa*) is good material. Teachers must experiment with available leaves and see which are best.)

*b.* Let each child crush leaves between white paper and observe the green stain. He probably knows that this stain, made by leaf-green, is not removed from white clothes by ordinary washing. Why not?—Because leaf-green does not dissolve in water. What could we use to remove such stains?—The next experiment will provide the answer.

*c.* Remove the leaf-green from leaves as follows. Pick some leaves from a plant that has bright green, *soft*, thin (not tough-skinned) leaves. Have some water ready boiling in a tin and boil the leaves for a few minutes. Pour a little alcohol (methylated spirits) into a smaller tin and put the leaves in it. Now warm the alcohol gently by placing the small tin in the larger tin (Figure 40). (Be very careful: hot alcohol catches fire easily.) Soon a clear, green liquid will be obtained; this is a solution of leaf-green. Pour it into a glass vessel.

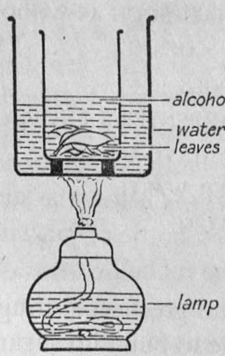



FIGURE 40.—How to warm green leaves in methylated spirits

*d.* Make a fresh stain by crushing a green leaf on a white cloth. Ask the class how to remove the stain. The best method is: place the cloth stained side *downwards*, on a pad of clean rag; dip a small rag

in alcohol and press it over the stain. Keep on doing this and move the cloth to a fresh place on the pad until the stain is removed. The alcohol dissolves the leaf-green and carries it through on to the pad.

*e*. Show that oxygen is given off from green leaves in bright sunlight, but not in dull light. You will need some pond-weed in water in a glass container. Use any kind of plant with leaves that grow *under* the water (not on the surface). Put it in a glass jar. Place the jar in sunlight and notice the stream of bubbles given off by the leaves. Move the jar into a well-shaded place; at once the stream of bubbles slows down and then stops. By questioning, get the children to think about what they have seen:—

Where are the bubbles coming from? What happens to them? Of what do the bubbles consist?

The natural answer will be 'Of air'; do not contradict this. Ask them to wait until the end of the experiment before deciding.

If this gas comes from inside the plant, how does it get out? (Your introduction has shown them that there are small holes in the leaf skin.)

Now collect a small tube or bottle full of this gas. Figure 41 shows two different ways of arranging the experiment. For method (*a*), use a deep glass tank, or a white basin, and a funnel with a short stem, so that the top of the stem is below the surface of the water. For (*b*), fit a wide-mouthed bottle or jar with a cork: bore a hole in the cork to take a large funnel. Whichever method you use, the next step is as follows: take a small bottle *full* of water; close the mouth with your thumb and invert it over the stem of the funnel in (*a*), or under the water in the funnel in (*b*). When the bubbles have filled the bottle with gas, again close the mouth and remove it. One of the children holds a thin, dry splinter of bamboo or wood; he now lights it, blows out the flame and, when the end is just glowing, pushes this

glowing splinter into the bottle; it will *re-kindle* and burn brightly for a moment.

Control experiment: push a glowing splinter into a bottle of ordinary air. It does not burst into flame.

The children are now in a position to deduce that the gas given off from the leaves is *not* ordinary air. From their previous lessons on burning they may guess that the gas is mainly oxygen; but they cannot say that they have *proved* this, because they have not previously been able to collect and test a sample of oxygen.

(If you tell the children at the beginning what you intend to

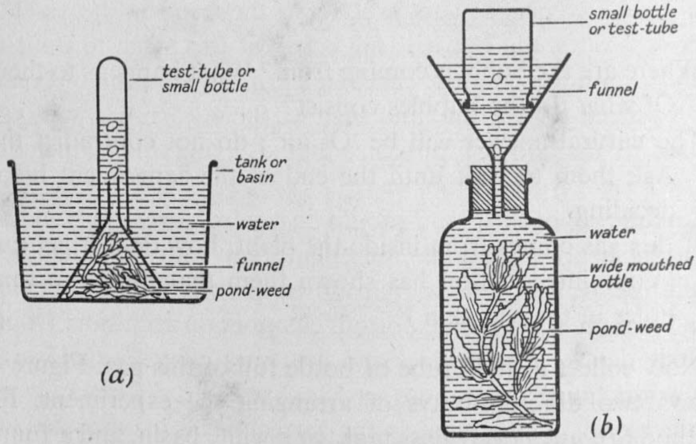



FIGURE 41.—Two methods of showing that green leaves give off oxygen in bright sunlight

prove, you completely spoil the lesson as an exercise in drawing conclusions from observations, i.e. deduction.)

This experiment is so valuable that every teacher who can possibly do so should practise it, and do it with his class. It is the only opportunity the children will get, in the Primary School, of preparing a sample of oxygen and of seeing how it assists burning. It also gives an opportunity for seeing if the children understand what they have learnt before about air pressure.

After the experiment a diagram is made and the teacher can ask:—

Why did not the water fall out of the inverted bottle at first?
What caused the water to escape from the bottle? (The gas given off by the pond-weed pressed down on it.)

### (7) *and* (8). *Respiration and circulation*

Remember that breathing means the passage of air into and out of our lungs. The blood in the lungs takes up oxygen and carries it to every part of the body, where it is used to *burn* (or oxidize) part of our digested food; this *burning* process keeps us warm and gives us energy. This process in the body is the essential part of *respiration*, but it is far better at this stage to omit the term 'respiration'; let the children learn the meaning of breathing (external respiration) and then let them learn 'How Oxygen is used by the body'. Emphasize that all living things, including plants, use oxygen in this way.

Circulation of the blood should be treated very simply indeed. Treat the heart as a double muscular pump with four chambers. There is a wall of muscle right down the middle, but openings lead from the top into the bottom chamber on each side. Do not include details about valves and heart-beat. Try to avoid using the words 'pure and impure' or 'clean and dirty' when referring to the blood.[1] Unfortunately the correct terms (oxygenated and de-oxygenated blood) are difficult at this stage. However, it is perfectly possible to speak of 'blood containing much oxygen' and 'blood containing little oxygen' as in the following explanation.

The left side of the heart receives from the lungs bright red blood containing much oxygen. The left heart-pump sends this blood through the arteries to every part of the body. Oxygen is used to burn up part of our food, and carbon dioxide is set free.

[1] 'Venous and arterial blood' should also be avoided as they are misleading when the pulmonary circulation is considered.

When the blood has lost most of its oxygen, it becomes dark purplish-red; the blood which carries away the carbon dioxide travels through the veins to the right heart-pump; this sends it to the lungs, where carbon dioxide is given up and fresh oxygen is taken in.

Capillaries should be mentioned. It is useful to compare the blood vessels to roads. The heart is like a big town; a great road leads away from it, but only traffic going *away* from the town is allowed on this road. It branches into smaller and smaller roads which lead finally to many little forest paths (capillaries). These lead into roads again (veins), which all join to form one great highway by which returning traffic enters another part of the town.

(Use a very simple diagram similar to Figure 43.)

Clotting of the blood should be mentioned in connexion with First Aid.

*Practical work*

*a*. Feel the windpipe and voice-box. Feel the rib movements during breathing. (The mechanism by which air enters and leaves the lungs is not taught at this stage, but the children should be aware that both ribs and diaphragm play their part in breathing movements.)

Supply a piece of string for each pair of pupils. Get them to measure each other's chest expansion. Make marks on the string to show the chest measurement at its smallest and at its greatest. The teacher may write up the results on the board and as a home exercise the children can find the class average and each compare his own expansion with the average.

*b*. Prepare some fresh lime-water (see p. 39) and breathe through a tube into it. Carbon dioxide turns lime-water milky. Blow some air through lime-water by means of a bicycle-pump or rubber tube with bulb.

*c*. (i) Let each pupil time his normal rate of breathing when sitting still, by counting while the teacher times one

minute on a watch or clock. Then let him take vigorous exercise, such as 'running on the spot'. At once he should sit down and time the rate of breathing again. Energy has been used up, so the body needs more oxygen and has more carbon dioxide to get rid of.

(ii) Let the children feel their pulses. Let each pupil time his pulse so that he knows how many times his heart beats in one minute. Let him take vigorous exercise and time it again. (Figure 42).

*d.* Observe veins, e.g. on backs of hands and in the wrist. Arteries lie deeper; it is especially important that they should not be injured. Also they have such thick walls that the blood does not show through them as it does in veins.

FIGURE 42.—'Feeling one's pulse'

*e.* If possible, examine an animal's heart obtained from a slaughter-house, or that of any freshly killed mammal. Observe the blood-vessels which, like pipes, either bring blood to the heart or take it away. *Do not name these or attempt to describe them in detail.* Insert straws or strong leaf-stalks into the cut ends of the blood-vessels, and then cut the heart open length-wise and show how the straws indicate the 'openings' by which blood enters and leaves the heart chambers. Notice the thick, strong walls of the two lower chambers, which pump blood out of the heart.

*f.* Use a rubber tube with a bulb to pump water out of a basin; the whole tube should be full of water at the start. The 'heart-pumps' force blood from the heart in much the same way.

*g.* Here is an idea for an outdoor demonstration which may give children a clearer picture of the course taken by the blood. It can only be attempted after the children have had lessons on the subject and have made a diagram in their notebooks.

*Materials:* A good supply of 'tickets', half of them labelled

'oxygen', the other half 'carbon dioxide'. Use two distinctive colours, e.g. white for oxygen and yellow for carbon dioxide. If the tickets are cut before the lesson, it is a simple matter to get each child to prepare either two or four labels.

Twelve to sixteen larger pieces of paper coloured red on one side and blue on the other.

*Procedure:* On flat ground outside draw a plan, as in Figure 43. Draw with chalk on concrete, or with a stick on soft ground. Choose three or four children to represent the body tissues; station them at BBB. Choose twelve to sixteen children to represent blood; station them at intervals around the 'course' and give to each a coloured paper and a 'ticket'. Those on the right-hand side of the plan hold oxygen tickets and show the red side

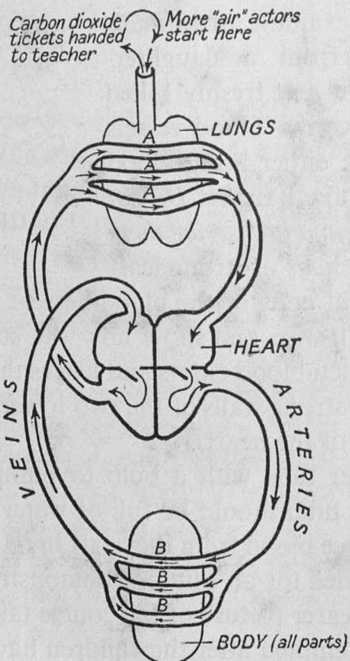



FIGURE 43.—A diagram for a simple demonstration of the circulation of the blood

of their paper; those on the left show the blue side of the paper and hold carbon dioxide 'tickets'. The rest of the class represent air, and at the beginning all of them hold oxygen 'tickets'; three are stationed in the lungs, the rest outside. The remaining carbon dioxide 'tickets' are held, concealed, by the 'body' actors.

At the word 'Go' the 'blood' begins to circulate and the 'air' to move in and out of the lungs. Each child as he reaches B gives up his 'oxygen' ticket, receives a 'carbon dioxide' in exchange and must remember to reverse his coloured paper. When he reaches A he hands in his 'carbon dioxide', which is carried out of the lungs, and receives a new 'oxygen' ticket, again reversing his coloured paper. When all the 'oxygen' has been used, i.e. has passed into the hands of the 'body' actors, the process can be repeated with different children taking different parts.

If this demonstration is to be worth the time it occupies, the children must understand and co-operate.

Discuss the whole plan in the classroom first, using the diagram in the children's notebooks for guidance. After the demonstration there should be a discussion on these lines:—

*What the demonstration showed*

1. The path taken by the blood as it circulates.
2. It is in the lungs that the blood receives oxygen and gives up carbon dioxide.
3. It is in the body (legs, arms, head, stomach, every part) that the oxygen is actually used and carbon dioxide produced.
4. Oxygen is not red, nor carbon dioxide purple, but blood containing much oxygen is bright red in colour: the blood becomes purple when oxygen is taken away.
5. The same blood goes round and round, but that carrying much oxygen is kept quite separate from that taking away carbon dioxide.

*What the demonstration failed to show*

1. The air which leaves the lungs still contains some oxygen, but it has a greater proportion of carbon dioxide than the incoming air.
2. The heart was represented as doing no work at all.

It would be easy to think of other points not shown by the demonstration. (Only one lung was shown instead of two.)

### (*9*). *Removal of waste products from the body*

The work of the kidneys is to remove waste substances and water from the blood. The water containing waste substances is called urine. No further information about the work of the kidneys is required at this stage.

*Maintenance of steady body temperature*. The children know that evaporation causes cooling, so they can understand how sweating reduces body temperature. In hot, *dry* climates we say that we do not sweat so much as in damp climates, but this is not so; the sweat evaporates immediately, leaving the skin dry, though 'dirty' from the deposit of salts. This rapid evaporation is a great help in preventing us from becoming excessively hot. Refer also to the evaporation of water from leaves; this also prevents overheating.

The hygiene of skin and clothing is important (see p. 164) and should be discussed at this stage.

### (*10*). *Waste products from plants*

This section does not require a separate lesson, but the idea of oxygen being a form of waste substance will seem very strange to the children. Here is an opportunity to show that a 'waste substance' is something not needed by the living thing; it is not necessarily 'dirty'. When plants give off their waste oxygen they are keeping the air 'pure' for men and other animals.

### (*11*). *Movement: skeleton and muscles*

There is no need to teach the names of the individual bones. A large drawing of the human skeleton is useful, but it is not essential; a few schools may be able to borrow such a chart from a neighbouring Secondary School. The children can feel their own bodies and locate the *skull*, *backbone* (composed of many small bones), *shoulder-blades*, *collar-bone*, *breast-bone*, *ribs*, *hip-bones* and most of the *limb bones*. It is easy to discover that the forearm contains two bones, and the two bones of the lower leg may be felt at the ankle. Details of the bones in hand and foot are not to be taught at this stage. The important points to bring out are:—

(*a*) Some of the bones protect internal organs.
(*b*) The skeleton supports the body.
(*c*) Some bones are jointed in such a way that movement is possible and yet the joint is strong.
(*d*) Bones are a living part of the body; children's bones are growing and hardening.
(*e*) Muscles form the main part of our flesh. (Lean meat is chiefly muscle.)
(*f*) Muscles are attached to the bones by tendons. When a muscle gets shorter and thicker it pulls a bone and so part of the body moves.

*Practical work*

*a*. Feel the positions of the main bones.

*b*. Examine any animal bones that you can collect. Try to get the leg-bones of a small animal; notice their smooth, rounded ends.

*c*. Let each pupil feel his biceps muscle as he bends and straightens his forearm. Then raise the heel, pressing up on the toes, and feel the muscles of the calf (lower leg). Let the pupils find tendons, e.g. in the wrist, heel, back of the knee, front of

the armpit. They can experiment, by making different movements and by handling muscles, to find out where these tendons are attached.

*d.* Obtain the leg of a freshly-killed fowl and show how the toes are moved. The muscles which bring about the toe movements are the flesh of the leg which we eat; before cooking, the leg is usually cut off below these muscles, but the long tendons remain.

Let the class come up in groups and see how they can move different toes by pulling different tendons.

### (*12*). *Sense organs; brain and nerves*

A few simple demonstrations will bring home to the children that *we find out what is happening around us by means of our eyes, ears, skin, nose, tongue and mouth.*

*Practical work*

*a.* Blindfold two or three children. Give them a few simple commands such as: 'Write your name on the blackboard', 'Go and sit on that chair in the corner', and lastly, 'Read a sentence from this book'. Blindfold another child. Hand him a box containing three objects. Then ask him: 'What is this and what does it contain?' Do not make the test too easy, and try to arrange it so that the sense of smell is used in addition to that of touch. For instance, you might use a coin (ask the child to name the kind of coin), a lime fruit and a piece of soap.

A short discussion follows. How could the children tell what the things were when they could not see them? They used their *sense of touch* and their *sense of smell.* What other ways are there of knowing about things around us? Do the next four experiments:—

*b.* Blindfold another child and tie his hands behind his back. Stand him close to the table and ask if he can tell the two things you put on the table in front of him. Choose either two things with strong distinctive smells such as an open tin containing a

spice and a freshly peeled orange, or choose one thing that you can smell and another that you can hear (e.g. a clock).

*c.* Ask everyone in the class to turn their backs on you and to shut their eyes. Tell them to see if they can describe what you do. Perform a few actions which can be interpreted by *hearing*, e.g. walk across the room and unlock a cupboard; tear paper; write on the blackboard; yawn.

*d.* Tell the class to sit perfectly still for one minute, or better, take them out and stand for one minute. At the end of the time make a list of the different sounds heard.

*e.* Tell the children to put their fingers into their ears and pretend they are deaf. Give some simple command; repeat it with looks of annoyance when they do not respond; finally try to indicate by gestures what you want them to do.

By discussion make clear that we use all our senses to find out about things. Our senses make us aware of what is going on around us. The sense of taste is only concerned with feeding. If a person loses the use of one sense he is severely handicapped, even though he may become very clever at using the other senses as substitutes for the one he has lost. We should never laugh at such unfortunate people, but should do all we can to help them. Tell something of work for the blind and of what blind people can learn. Also explain how a deaf person can learn to read speech by watching the speaker's lips and mouth.

Next consider the question: 'How do we make use of the information that our senses bring us?' Ask:

'What do you do if you pick up something which is very hot?'

'What would you do if you suddenly saw a dangerous snake lying across your path?'

'What would you do if you heard a motor-car (or a dangerous animal) close behind you?'

By discussion bring out that, if one of your senses makes you aware of something dangerous, you *move* immediately in a way that saves you from the danger.

What makes your legs and arms move? The muscles attached to the bones. The muscles are controlled from the brain, which receives messages from the sense organs. The nerves, which look like fine white threads, stretch from all the sense organs to the brain. Other nerves stretch from the brain to the muscles, and they take messages from the brain; thus the brain 'tells' the muscles to move the body, although no words are spoken. The brain is very delicate and easily injured, so it is enclosed in the strong bony skull. Most of the nerves pass down inside the backbone, and branch nerves go out from the backbone to the body. Discuss dangers of injury to the head and back.

Next take lessons on the care of the eyes and ears.

## HEALTH TEACHING

The work is to be closely linked with the lessons on how the body works. Take each section outlined here as part of the appropriate section under 'Living Things'.

### *In connexion with the digestion of food*

Care of the *teeth.* The structure of a tooth (very simply). Milk teeth and permanent teeth. The necessity for thorough chewing, for regular mealtimes, for rest after meals, for daily bowel movement.

### *In connexion with breathing and the circulation of blood*

Correct breathing; good posture. The need for fresh air and ventilation. The effect of exercise on breathing.

### *In connexion with the removal of waste*

Care of the skin; cleanliness. Some skin diseases, e.g. ringworm, scabies, yaws, leprosy.

Clothing: cleanliness, suitability, amount.

Keeping cool; the avoidance of sudden chilling and of wet clothing. The need for drinking sufficient water. Normal body temperature and fever.

*In connexion with muscles, nerves and sense organs*

The need for the exercise of all muscles. Good posture. The need for sleep, rest and relaxation.

Care of the eyes. Infectious eye diseases.

Care of the ears.

*Animal parasites*

Select the most prevalent in your district. Choose some blood-sucking parasites, e.g. fleas, ticks, jiggers, lice; some internal parasites, e.g. hookworm, roundworm, malaria parasite.

*First Aid*

How to stop bleeding from cuts and from the nose. The treatment for ringworm, scabies, small burns.

## EARTH AND UNIVERSE

*Main ideas to be brought out*

1. Night and day are not the same length throughout the year.
2. The apparent path of the sun through the sky is not the same throughout the year.
3. Changes in the length of night and day are due to the fact that the axis of the earth is not 'upright'.
4. The tilt of the earth's axis causes winter and summer in regions far from the equator.
5. The crust of the earth is made up of rocks which contain valuable minerals.
6. The surface of the earth is being constantly worn away by the action of water, wind and heat changes.
7. Sand and mud which sink to the bottom of water on the earth can be changed into rocks again after millions of years. They are changed by being compressed and heated.
8. There are also rocks under the sea. Land and mountains are parts of the earth's crust that have been pressed upwards.
9. The remains of plants and animals that lived on the earth

long ago have been found in some rocks. Many of them were different from the living things that we find today.

10. *Coal* is made from the remains of great forests which grew in swamps long ago.
11. *Fuel oil* is found in some rocks. From it are obtained petrol, kerosene, oil for Diesel engines, lubricating oil.
12. *Soil* is formed from rocks and from the remains of dead plants and animals.
13. Plants use minerals from the soil; men and animals eat plants; so we have something from the earth's crust in our bodies.
14. When we burn wood or plants, the ashes are the mineral part taken from the soil-water.

You have probably read books in which the cause of the seasons is clearly explained. Many of these books are written chiefly for people who live in temperate regions which have winter and summer as their main seasons. Most teachers who use this book will live within the tropics; there the 'seasons' do not depend so much on the fact that the earth revolves round the sun on an axis that 'slants'. It may even happen, as in parts of West Africa, that the hottest season is the one when the days are shortest and the sun's path is at its lowest in the sky. So if you live where the seasons are 'Wet and Dry' rather than 'Hot and Cold' avoid referring to 'seasons' in the lessons which follow. Then introduce the subject of seasons when you reach Main Idea 4.

At schools situated very near the Equator the variation in time of sunrise and sunset, and changes in length and direction of shadows, may be only slight.

### (*1*). *Length of the day and night*

*Practical work*

At the beginning of the school year discuss these questions:—

Are nights and days always of the same length?

Does the sun always appear to rise and set in the same place?

Arrange to make records to find out the answers to these questions. In rural communities which take their time from the sun, having no clocks, it may not be possible for the children to observe hours of sunrise and sunset, but they can observe the position of the sun with reference to some fixed landmarks and so find out that the sun does not always rise in the same place. Where there are clocks in the homes, children can be asked to note the times of sunrise and sunset on, say, the twenty-first day of each month throughout the year. Put up a chart and keep the records in the classroom.

How long are the longest and the shortest days in the part of the earth where you live?

### (2). *The sun's apparent path through the sky*

*Practical work*

Use a shadow stick to record, as often as possible during the year, the changes in length and direction of the shadow thrown by the sun. The children will already be familiar with the fact that the recording of movements of shadows is an indirect way of showing the sun's apparent path through the sky. This year

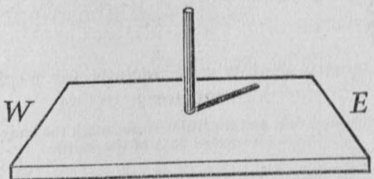



FIGURE 44.—A shadow stick

the work should be done more regularly and in more detail. Get a *flat* board, about 18 by 12 inches; in its middle mount a short, straight stick, like a pencil, 6 to 8 inches long, as shown in Figure 44. Make sure the stick is really upright and not leaning over in any direction. (This method is better than that of using a post in the ground, for two reasons: first—it makes it

easier to keep the records and to show, at the end of the year, how the sun's position appears to change; second—the apparatus is small and can be kept safely when not in use.) The board should be placed so that its length runs east and west, and it should always be put in the same place. Choose a spot where the ground is quite flat and keep it clean and smooth. Short pegs can be driven into the ground round the edges of the board and left to mark the exact place.

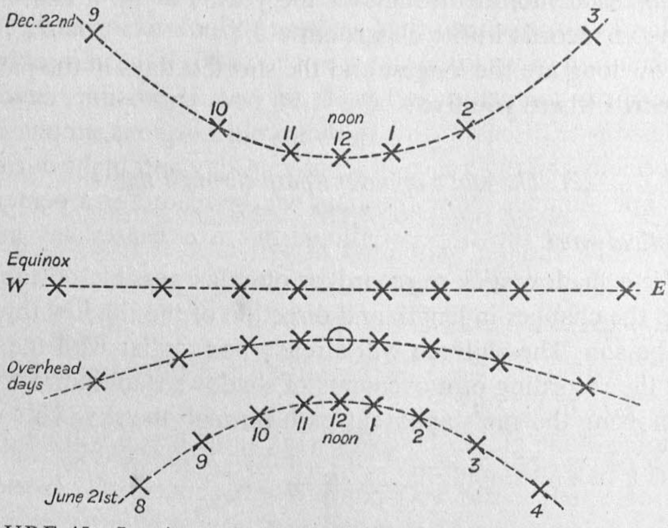



FIGURE 45.—Imaginary shadow stick records for a place 10° N. of the equator

(O is the position of the shadow stick, and the little crosses mark the ends of its shadow at various hours on various days of the year.)

If possible mark the shadow at hourly intervals during the day. In each case draw a curve through the tops of the shadows and write the date on the board alongside the line. Figure 45 gives some records for an imaginary place 10° north of the Equator. Towards the end of the year, have a lesson in which the children discuss the whole set of observations and the conclusions which can be drawn from them.

If the school is in session, be sure to make records on the days

when, at the place where you live, the sun is directly overhead at mid-day.

### (*3*). *Changes in the length of day and night*

Later in the year, when you will have the shadow-stick records to help, discuss the question: Why does the sun seem to take a different path through the sky at different times of the year? Get the children to tell what they already know: that the sun seems to move across the sky because the earth is moving. This should give the idea that we have to look to the earth for an explanation of what the sun seems to do. Tell the class about the seasons in temperate and polar regions. If possible, devote some lessons to discussing life in these colder regions, emphasizing especially the difference in lengths of day and night during winter and summer. Now the class will be ready for a demonstration of how the slope of the earth's axis causes day and night to vary in length.

*Practical work*

To show that the slope of the earth's axis causes nights and days to vary in length:—

A home-made globe stand is useful, though you will need a thin stick or knitting-needle as well.

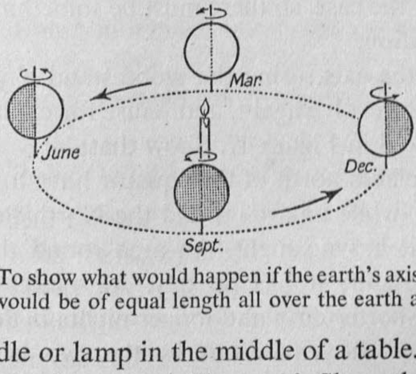



FIGURE 46.—To show what would happen if the earth's axis were 'upright':—days and nights would be of equal length all over the earth all the year round

Place a candle or lamp in the middle of a table. Draw a large circle and put in dates as in Figure 46. Show the ball or fruit

which is to form the model earth. Mark the equator and get the children to name the North and South Poles. Now mark one 'noon line' (line of longitude); put three or four very short match-sticks on the line in the positions shown. Attach them as suggested in Expt. *c*, p. 108. Mount 'the earth' on a knitting-needle, light the candle and say: 'Let us suppose that the earth spins on an upright axis; let us see what kind of nights and days we should get if this were the case.' Spin the earth and make it revolve round the sun, keeping the axis upright all the time. Show that, with this arrangement, all parts of the earth get nights and days of equal length all the year round. But we know

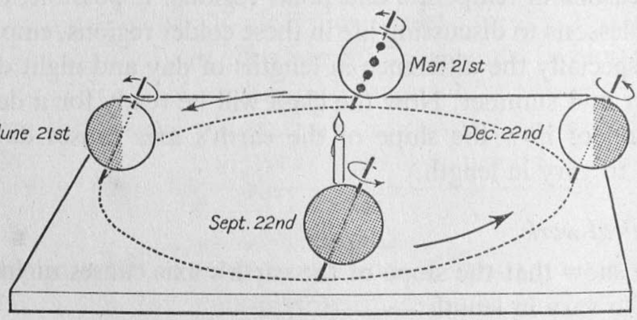



FIGURE 47.—To show that days and nights change in length because the earth's axis is 'tilted'

that this is not the case, so there must be something wrong with our demonstration.

Now slope the axis, using the globe stand if you have one. Make the earth revolve again, and pause for explanation at the positions marked in Figure 47. Show that:—

In *June* all places north of the equator have longer days and shorter nights, while an area round the North Pole is never in the shadow—it has no night. An area round the South Pole never sees the sun; it has no day. All places south of the equator have shorter days and longer nights in June.

In *December* the conditions in the two hemispheres are reversed.

In *March* and *September* all regions of the earth have days and nights of equal length.

It may be advisable to discuss, with blackboard diagrams, what was seen in the demonstration and then, if necessary, to have a second demonstration.

### (*4*). *The seasons*

You have now shown why days and nights vary in length, but you have not explained winter and summer in regions far from the equator. Quite commonly pupils get a vague idea that, when one hemisphere is tilted towards the sun, it receives more heat because it is nearer to the sun. This of course is quite wrong, since the sun is much too far away for this to make any difference. Again, the northern hemisphere does not have hotter weather in summer *because* the days are *longer*. It is mainly a question of *how much* sunlight is received.

*Practical work*

Darken the room. Make a tube of thick brown paper and slip it over the end of an electric torch. Shine the light directly on to a sheet of white paper. Now slant the torch. Change the angle several times and note that when the rays are vertical the spot of light appears *smaller* and *brighter*. The same amount of light is concentrated in a smaller area than when the rays are slanting, so naturally the light is brighter. If we could feel the heat from the torch, in which of the spots of light should we feel hottest?

With the help of diagrams (Figure 48) show that:

1. At noon near the equator the sun's rays strike vertically; further from the equator the rays are slanting (I).
2. When one hemisphere is tilted towards the sun, the sun's rays strike it more directly than they do when it is tilted away from the sun (I).
3. Slanting rays must pass through more air before reaching

the earth. This also makes the sunshine less hot when it reaches the earth's surface (II).

*(5)–(14). The earth's crust*

These ideas suggest in simple outline an account of:—

How rocks are formed.
Useful things that are obtained from rocks.
How soil is formed.

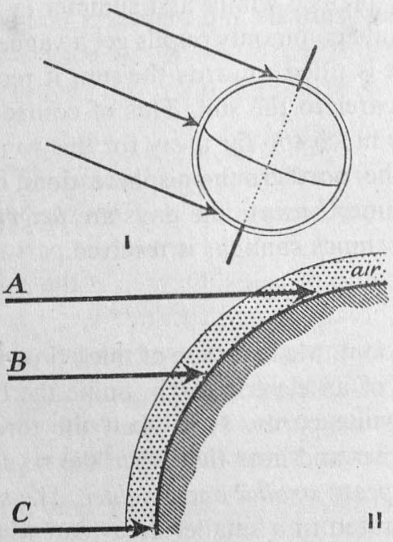



FIGURE 48.—To show how the sun's rays strike the earth
The light at A passes through more air than the light at B, and through still more than the light at C.

There is no need to spend long over this section; give the broad ideas, with emphasis on special aspects that are of interest in your area. If there are mines, the children will want to know more about them; if possible arrange for a visit and give a simplified account of operations at the mine.

How the earth's surface is worn away, how sediments are deposited, and eventually changed back into rocks, is all explained in school geography text-books.

The subject of Coal and Fossils will enable teachers who have read widely to introduce the *idea* of evolution. The word should not be mentioned, but the children may learn that the world is very, very old. It has been changing slowly for many millions of years and is still changing today. Plants and animals have changed too, and fossils show us that there were many strange living things long ago. Nearly all of them are sufficiently like animals and plants of today for us to say: 'This was a fish', 'This was a reptile', and so on, but they differed very greatly from present-day animals and plants.

## MATTER AND ENERGY

*Main ideas to be brought out*

(1) We get heat from the sun and by burning fuels.

(2) During burning, breathing and rusting, part of the air is used up; things cannot burn in the part which remains.

(3) Air is a mixture of gases. Oxygen is the gas responsible for burning, breathing and rusting.

(4) When fuels burn and when we breathe, carbon dioxide and water-vapour are produced.

(5) Fire can be dangerous as well as useful.

(6) Things get larger when they are heated; they get smaller when they are cooled.

(7) Heat passes from a thing which is hotter to one which is cooler. Heat travels more easily through some substances than through others.

### (*1*). *Sources of heat*

Even in tropical countries people sometimes need a fire for extra warmth, and, however hot the days, they use fire for cooking. Discuss primitive ways of making fire; these depended on rubbing (friction) and on having some substance which would burn very easily. Nowadays we use matches; these depend on the same two things.

*Practical work*

*a. Friction produces heat.* Rub the hands together briskly. Draw a short piece of string quickly between your finger and thumb. Describe accidents when a man's hands have been 'burnt' by having a rope slide quickly through them. Rub something with a piece of sandpaper and then feel the surface afterwards. You may be able to watch a man sharpening knives on a grindstone. Why does the stone dip into water as it turns?

*b. Matches.* Feel the heads, feel the striking surface on the box. Strike a match: you have started a small fire: friction produced heat, just enough heat to make the substances in the match-head burn. These substances catch fire easily. The kind of match with a red head will light if struck on any rough surface; the more usual kind of match is called a safety-match because it will only light if rubbed on the specially prepared surface of the box.

*c. Collect samples* of all the things which are used as fuel in your country, e.g. wood; show different kinds of firewood (naming the tree that each comes from); different parts of palm trees; charcoal; animal dung; kerosene; coal; vegetable oils for lamps. Discuss the advantages of each for the purposes for which it is used.

### (2). *Burning, breathing and rusting*

*Practical work*

*a.* Float a short piece of candle on water. Light the candle and invert a glass jar over it so that the mouth of the jar comes just below the surface of the water. When the flame goes out, note the level of water inside the jar.

Repeat the experiment and this time slip a piece of cardboard under the mouth of the jar while it is still under water. Lift it out, candle and all, and plunge a burning splinter into the air in the jar. Now plunge a burning splinter in a jar which has not had anything burnt in it.

*Discussion:* Why did the water rise in the jar? Some of the air was used up; the water took the place of the air which was used.

Why did the candle go out when there was still air in the jar? It appears that only part of the air is able to help burning.

*b.* Repeat experiment *a* using, instead of the candle, a *small* spoonful of methylated spirit on a tin lid. Do it again using kerosene instead of the spirit.

As a result of these experiments, we reach the conclusion that:

*When things burn they use up part of the air. The part of the air which is left does not allow things to burn in it.*

*c.* Get three glass jars and make two small bags of mosquito netting. Put some earthworms into one bag and put into the other some grasshoppers, cockroaches or any other large insects. Tie the bags to two sticks and put them into two jars which are inverted over water, as in Figure 49. The third jar contains only air (i.e. it is 'the control').

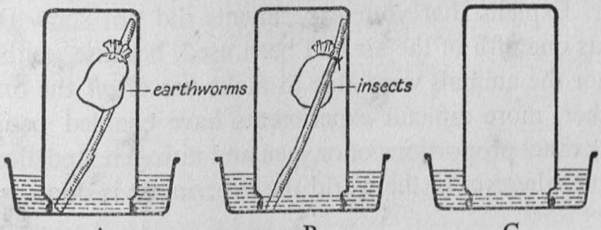



FIGURE 49.—Does breathing use up part of the air?

When the water ceases to rise in A and B, lift the three jars out of the water, slowly and carefully, keeping them inverted. At once, test the air inside each by plunging in burning splinters.

What conclusions can we draw? It seems that the living earthworms and insects behave like the burning candle and fuels; they all use up part of the air.

This is a most important series of experiments; it brings home

the close resemblance between breathing and burning. If possible, complete the series by doing the next experiment:—

*d.* Get some *bright* iron filings from a blacksmith, or file them off a piece of iron yourself. Wet a large glass jar inside and coat the inside with filings. Invert the jar over water, mark the level of the water inside it, and leave it for a few days; mark the new water level. Test the remaining air with a burning splinter.

*Note:* If the filings are very coarse and do not cling easily to the inside of the wet jar, they can be tied in a little bag of wet cloth.

The children may now conclude that: *Burning, breathing and rusting all use up part of the air. Things cannot burn in the part which remains.*

### (3). *Oxygen and nitrogen*

After carrying out the experiments in the last section, teach that air is a mixture of gases in the proportions of one-fifth oxygen to four-fifths nitrogen and a very little carbon dioxide. Do not forget that there is also a varying quantity of water-vapour. Explain that your experiments did not show that so much as one fifth of the air had been used, because neither the fuels nor the animals were able to make use of *all* the oxygen; but other, more difficult experiments have enabled people to find the exact proportions of oxygen and nitrogen, and these are the same wherever in the world the experiment is done.

### (4). *Products of burning and breathing*

*Practical work*

*a.* Place a clean, dry glass jar over a lighted candle and notice the moisture that forms inside.

Light a kerosene lamp: close observation shows a 'mist' on the lamp chimney just after the lamp is lighted. This moisture soon disappears because the chimney becomes hot and so does not cause condensation; therefore the water produced by burning goes away unnoticed in the form of water-vapour.

This is a new idea—burning *produces* water!

*b.* Breathe on to a mirror or slate. Clean a picture glass by breathing on it and then rubbing. Thus show that the burning in our bodies also produces water.

*c.* Fresh lime-water is needed for the following experiments, see p. 39, (Chap. III).

Make a little wire holder for a bit of candle; lower the lighted candle into a glass jar and cover with a plate. When the flame goes out, remove the candle and quickly pour in some fresh lime-water. Cover and shake. Now pour some lime-water into a similar jar of fresh air, cover and shake. Compare the results.

*d.* Put some fresh lime-water into a jar and blow into it through a tube. Put the same amount of lime-water into another jar; blow air into it by means of a bicycle-pump or bellows. (Remove the nozzle after each downstroke so that water cannot enter the pump.)

*Conclusion:* Burning and breathing both produce some gas which turns lime-water milky. The gas is carbon dioxide.

*Note:* This will be a good point from which to start the lessons on Living Things.

### (5). *The dangers of fire*

Discuss fire dangers in the home and in the community. How are fire accidents caused? How can they be prevented? How can we put out a fire once it has started?

Some substances burn more easily than others: make a list of some of these; arrange them in order, starting from those which burn most easily.

Some form of heat is needed in order to start a fire, e.g. heat from the sun, sparks, flames, charcoal, electricity. Once started, the fire will only continue if it is supplied with fuel and oxygen, so we can put out a fire by cutting off either the supply of fuel or the supply of oxygen. In most cases it is the oxygen that we cut off. Consider different ways of putting out fires, e.g. with

sand, water, a large blanket or cloth. When there is a very big bush fire we cannot remove air from the flames, so men try to remove the fuel by clearing the trees and plants over an area towards which the fire is advancing.

Water cannot put out burning petrol, oil or fat, because these float on the surface of the water and then burn more brightly, since the fire is spread out and can get plenty of air.

## (6). *Expansion due to heat*

*Practical work*

*a.* To show that a wire becomes longer when it is heated. Tie a piece of wire to the top of a chair-back. On the bottom of the wire tie a ruler (or a longer strip of wood), so that one end is just under the bottom bar of the chair (see Figure 50). Let a child measure the distance from the ground to the tip of the ruler. Now heat the wire in the middle with a candle flame. (Put a plate or newspaper underneath to catch the drops of wax.) As the wire gets hot, the ruler dips downwards because the wire becomes longer. The small movement of the bottom of the wire is magnified by the long ruler. Measure the new height of the tip of the ruler. Remove the flame and watch the end of the ruler rise up again.

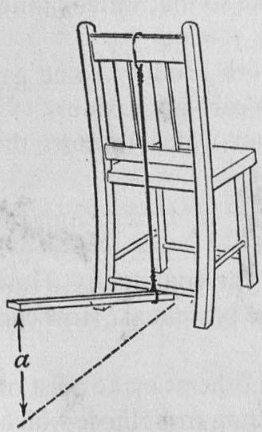


FIGURE 50.—To show expansion due to heat

(This simple but interesting experiment should be done in every school.)

Try this different form of the same experiment. Use some melted wax to fasten a straw to the ruler. Dip the tip of the straw in ink and hold a piece of stiff paper so that the straw just touches it. Now the movement of the wire, still further magnified, will be shown by an ink line on the paper.

*b.* Fit up the apparatus shown in Figure 51. If you fill the bottle with coloured water and then press in the cork, the water will rise a short way up the tube. Mark the position of the water either with a rubber band or a narrow strip of gummed paper. Heat the bottle *gently* (by holding it in warm water) and watch the water rise in the tube. Leave it to cool and notice that the level falls.

Why did the water rise? The heat made it expand: it occupied more space. You have made a 'water thermometer'.

*c.* Let the children learn to read a thermometer. Keep a record of air temperatures; take readings three times a day. If the class understands graphs, record the results graphically.

*d.* Find the temperature of boiling water. Do not let the thermometer rest on the bottom of the tin, or else you will take the temperature of the tin and not that of the water. Make the water boil vigorously. Does this make any difference to the boiling temperature?

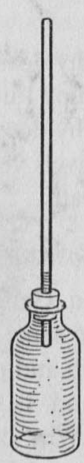


FIGURE 51. —To show that a liquid expands on heating

*e.* If you are able to get a toy balloon or a fresh animal bladder, you can show that air expands when heated. Blow up the balloon, not too tightly. Stick a narrow strip of paper (or tie a thread) right round it. Gently warm it, e.g. by placing it in the hot sun. What happens?

You have now shown that solids, liquids and gases become bigger (expand) when heated; they get smaller (contract) when cooled. Discuss common occurrences due to these facts. For example:—the laying of railway lines with small spaces between the sections. In some countries metal rims are fitted round wooden wheels: the iron is slipped over the wood when it is hot; then when the iron cools it contracts and fits very tightly. If bicycle tyres are pumped up very tightly on a cool morning,

and then the machine stands in the hot midday sun, the tyres may burst.

### (7). *Conduction of heat*

Why does the cook prefer to use a wooden spoon when stirring soup? Put a wooden spoon and a metal spoon in boiling water. Why does one handle feel so much hotter than the other? Heat travels very quickly along metal, which is a good conductor of heat.

*Practical work*

*a*. Get a metal (enamelled) cup and a drinking glass of about the same size. Stand a metal spoon in the glass. Half fill both cup and glass with nearly boiling water. Lift them, one in each hand. Is glass a good conductor of heat?

Why did we put a metal spoon in the glass into which we poured hot water? Glass cracks easily when suddenly heated, mainly because it is such a poor conductor of heat that the inner surface of a thick glass becomes heated before the outer, and the expansion on one side cracks the glass. The metal spoon conducts the heat away rapidly and so lowers the temperature of the hot water.

*b*. Examine kettle and cooking-pan handles. Do all the handles get hot when the vessel is heated? If not, can you explain why?

*c*. Lower a piece of copper mosquito-gauze over a candle flame. The flame appears to be cut off by the netting. This is because the metal conducts the heat away so rapidly that the wax vapour above the netting is too cool to burn.

Air is a poor conductor of heat. A thin layer of air, or bubbles of air, round a body helps to stop gain or loss of heat. For example, air, trapped in the feathers of a bird, helps to keep it cool in hot weather and warm in cold weather.

Why do we wrap ice in cloths? Why do we like to wear a woollen coat in cold weather?

CHAPTER IX

# Teaching Science in the Sixth Year

## LIVING THINGS

Children in this class are approaching the time when they will leave their Primary School. Some may enter a Secondary School; many more will become working members of their community, either in the home or as wage-earners. A part of their time for science this year should be spent in some project or projects connected with the life of the community. Such work will afford many opportunities for the revision of the science done earlier in the school course; it will emphasize the many ways in which school science can be applied usefully for the benefit of the community. A suggestion for such a project is given here, but it cannot be too strongly emphasized that a successful project can *only* be worked out in practical detail by those who live in the district concerned.

### *Outline of a project on 'Health in Our Community'*

*Preliminary discussion*

Is there much sickness in our village (or town)?

What are the various things which cause most illness locally?

Can conditions in our village (or town) be improved so that fewer people become ill?

Let us make a study of some of these conditions which affect health, and see if there is anything we can do to help in improving the health of our community.

*Water Supply*

Is it adequate? Is it clean? If not, how can it be improved? Can we help?

*Sanitary Arrangements*

*Latrines.* Are they suitably placed, properly constructed and covered?

*Disposal of refuse.* Are there incinerators? If not, can we build one?

*Housing*

Consider the various *types of building* and *roofing materials* used, their advantages and disadvantages. Are they the best available?

*General appearance*

Are the houses well spaced? Is our village kept clean and tidy? (Dirt and overcrowding endanger health.) How can we help?

Are there enough *shade trees*? If not, can we get permission to plant some?

*The market*

Is it well planned? What precautions are taken against spoiling food or infecting it? What special precautions should be taken in the case of meat, fish and milk?

*Diet* [1]

Is our diet adequate? If not, how can it be improved?

In town schools such a project might be replaced by a study of the Public Health Services, and of the local water supply and the refuse disposal arrangement, swith visits, if possible, to the departments concerned. It is most important to emphasize the necessity for co-operation between citizens, and between them and the authorities, and the responsibility of all for helping to keep the town clean and healthy. The pupils should also realize the importance of avoiding waste of water.

[1] Take the work on Food Requirements before doing this.

It is better to undertake one scheme of help in the community, and to do it properly, than to attempt too much.

In addition to a project the following subjects are suggested for study:—

(I) *Our food requirements and diet.* (This section should be taken in all schools.)
(II) *Reproduction* in plants, animals and man. To be followed up by sex teaching at the discretion of the Education Authority concerned, and if the Head Teacher considers it desirable.
(III) *Diseases and pests and their control.*
(IV) *Plants in the service of Man.*
(V) *Social animals.* (All schools are advised to take this section.)

### (I) *Food requirements and diet*

Body-building and energy-producing foods. Why the body needs each kind daily. The chief foods in which they are found. Protective foods which supply vitamins and mineral salts. Diseases due to lack of protective foods.

It is not necessary to teach the names of the vitamins. The most important thing is for the children to know what is meant by a *balanced diet.* Discuss this with reference to local foods, and emphasize the importance of those which supply body-building foods, the vitamins and mineral salts.

If possible plan the school-garden so that it helps to produce a balanced diet.

Malnutrition, its symptoms and dangers.

*Practical work*

*a.* To prepare starch from local starchy foods: mash the food thoroughly, adding a little water. Put the mashed wet foods into a bag made of muslin and squeeze well in water. Filter the liquid and the starch will be left on the filter paper.

*b.* To test for starch: Dilute some iodine solution until it is a

golden colour. Use a drop of this solution to test: (i) some dry starch, (ii) a solution of starch made by boiling it in water, (iii) some sugar, (iv) thin slices of various foodstuffs, vegetables and fruits. Make a list of the foods which contain starch.

*c*. To show that starch swells when heated:—

Heat some dry starch on a tin lid.

Compare the sizes of rice grains before and after cooking.

Heat a little water in a pan or tin. Put a spoonful of corn-starch in a cup and make it into a smooth paste with a little cold water. Add the paste to the hot water, stirring well, and allow it to boil. Notice how the starch swells up and makes the liquid thick, especially after cooling.

Why is it unwise to eat uncooked starchy foods?

*d*. To show that sugar and starch both contain carbon: heat strongly a little of each on a tin lid.

*e*. Heat small quantities of the following on tin lids: cooking-oil, fat, milk, meat. All become black because the food contained carbon. Notice that oil and fat catch fire and give out much heat when they burn: they are the energy-producing foods. Milk, meat and white-of-egg give off an unpleasant smell when they burn: this is a characteristic of the body-building foods.

*f*. To obtain the protein from milk: add a little acid such as lime-juice or vinegar; stir; the milk separates into a thick curd and a thin, watery liquid, and the two can be separated by filtering. The curd is mainly protein. Explain how, if milk is allowed to stand, the action of certain bacteria produces an acid which curdles the milk. In some countries curds are commonly eaten, and they form a most valuable food.

*g*. To obtain the protein from wheat flour: put some flour in a bag and squeeze it under water. Keep on squeezing with the fingers until the starch has passed into the water. The sticky mass that remains in the bag is wheat protein. If rice flour is available, repeat the experiment with this.

### (II) *Reproduction*

*Main ideas to be brought out*

(1) Living things grow up and eventually die, but they pass on life to their young.

(2) All animals and many plants start life as very small eggs inside the parent. The plant's eggs are inside the ovules within the seed-box or ovary. The animal's eggs are formed inside the female in a part called the ovary.

(3) Eggs can only grow into new plants or animals if they receive a tiny sperm from the male. Sperms are kept inside the male animal in the testes. The stamens of plants contain pollen which fertilizes the ovules.

(4) The young of plants and animals are small and delicate; they need to be protected and to have special food.

(5) Living things have taken something from both their parents. Seeds from healthy plants give better crops than those from weakly ones. Man can improve his crops and his live-stock by selection.

(6) Some animals lay many eggs and take no care of them; others lay a few large eggs which contain much food for the young. Mammals have very tiny eggs, which they do not 'lay': the fertilized egg grows in the mother's womb until the young one is ready to be born. After birth it is fed on the mother's milk.

(7) New plants do not always grow from seeds. Some are produced from underground stems, which have food stored in them. Others grow from stems which creep over the ground; others from 'cuttings'.

*Practical work*

*a.* To prove that pollen is necessary for seed production: use maize, which is easy to work with. Before the female flowers are fully grown, treat some of them as follows:—

i. Tie little bags of cloth or paper or cellophane over three flower-heads.

ii. Tie similar bags over three other heads. When they are full-grown take off the bags and shake pollen from ripe 'tassels' (male flowers) over them. Replace bags.

iii. Treat three more as in ii, but cut off the 'silks' (stigmas) before shaking the pollen over the female flower.

Record the results.

*b.* Make a collection of parts of plants, other than seeds, which are used for reproduction.

*c.* In the school-garden select seeds from the best plants for future use.

*d.* Use a 'rag doll' seed-tester to find if samples of seeds are suitable for sowing. Arrange the seeds on a piece of cloth which is then rolled round a stick and tied in position; place the stick in water so that the lower end of the roll just touches the water. After a few days unroll the cloth and count how many seeds have germinated.

### (III) *Diseases and pests and their control*

Study some animals and plants which cause diseases in Man and in his crops and livestock. Show the importance of co-operation in trying to control disease. Choose the diseases most prevalent in your district, including at least one plant-disease. Malaria and tuberculosis should be included in most districts. Explain the meaning of *vaccination* and *inoculation*.

### (IV) *Plants in the service of Man*

Choose one or more of the following groups and make a study of them, getting all the information you can from local people. Find out how the various products are prepared, arranging visits to watch the processes when possible. Make collections of the plants. Organize an exhibit to illustrate this class study:—

Medicinal plants.
Plants used for timber (for building, roofing or boats).
Plants from which are obtained:—oils; dyes; rubber; fibres.

### (V) *Social animals*

Choose one or two examples of social insects for study. The honey-bee and its ways have been studied in very great detail, and the whole story is full of interest, but in areas where bee-keeping is not practised it would be well to devote more time to the study of termites and ants.

*Practical work*

*a.* Visit an ant colony and watch ants at work. Dig into the colony and observe the different behaviour of soldiers and workers. Find the young ants, both larvae and pupae; as these are white they are often mistaken for eggs. The eggs are very small.

*b.* When swarms of winged ants appear, bring some to school and try to find from which kind of colony each comes. Often, if you dig into ant colonies just before the coming of the rains, you can find winged ants within.

*c. Termites* ('white ants') cannot be observed at work because they avoid the light. Break open termitaries; observe the behaviour and appearance of soldiers and workers. Note the cleanliness; there are no excreta, no food remains. Chopped grass (which is used as food) is found in some termitaries. In some there are fungus gardens; these appear moist and are different in colour from the rest of the termitary. Note that there are many different kinds of termites.

When a large termitary is being destroyed, try to obtain the royal cell. Break it open and find the king quickly before he can escape. You may be able to see the queen still laying eggs, and some of the workers attending to her.

*d.* Watch termites when the males and females swarm. Observe the pairs as they walk off, the female in front and the male behind. Put a pair on the surface of damp soil in a box. They may begin to dig a hole.

*e. Bees.* If there are bee-keepers in your district, arrange a

visit to one, and ask him to talk to the class and to show some fresh honeycomb. Some bees will allow him to open the hive and handle them without becoming angry.

*f.* Ask the class to find out which flowers are chiefly visited by bees. Ask them to watch bees visiting flowers and to notice the 'pollen basket' on their legs.

*g.* Examine an old piece of honeycomb. There should be one in the school collection.

## HEALTH TEACHING

The work for this year will be found under the heading 'Living Things'. It includes:—

*Nutrition and diet*

Whilst dealing with this subject it would be well to consider

*Methods of Keeping Food Fresh*:—
cooling, boiling and heat sterilization, smoking and salting.

*Diseases and pests and their control*

*Sex teaching* (optional)

*Public health*

Various aspects are suggested under the 'Outline for a Project'. If the teacher takes up some other project, he may wish to give separate lessons on such matters as disposal of refuse.

*First Aid*

What action to take in the case of more serious common accidents, e.g. severe bleeding, scorpion sting, snake-bite, broken bones, choking in a small child, fainting and shock, drowning.

General behaviour in cases of accident.

Be careful to teach the prevention of illness and accident as well as the best course to take for their treatment, and emphasize the necessity to avoid wrong treatment.

## EARTH AND UNIVERSE

So far the children have thought about the earth in relation to the sun and moon. They have also learnt that the stars are suns which are extremely far away. They can now consider:—

*The earth as part of the solar system*

*Main ideas to be brought out*

(1) The *stars* are very, very far away. With the help of telescopes men have mapped the sky and counted millions of stars.
(2) Constellations are groups of stars (which by chance may appear to us to resemble certain shapes or objects). They can be of use in helping to find the way at night.
(3) The stars are all round the earth, though we cannot see them in the day time.
(4) Stars have not got points and they shine with a steady light (although they appear to 'twinkle').
(5) The sun is one of the stars. It has a 'family' of nine planets, and our earth is one of these nine.
(6) All the planets move round the sun. Most of them are very different from the earth.
(7) Planets change their position in the sky. The positions of stars with reference to each other do not change. Planets give a steady light and do not appear to 'twinkle' as stars do.
(8) The lighted part of the moon is not always turned towards the earth, and this makes it appear to change in shape as it travels round the earth.
(9) An *eclipse* of the moon is caused when the shadow of the earth falls on the moon.
(10) An *eclipse* of the sun is caused when the shadow of the moon falls on the earth.

### *(1), (2) and (3). The stars*

Although stars can only be observed at night, teachers in some schools may be able to arouse interest in learning to recognize a few of the most striking constellations. Keep a class record throughout the year and find out in which months some of the well-known constellations can be seen in the evenings. A study of the constellations should bring out these facts:—

The stars appear to rise and set.

All the stars seem to move together as though they were fixed to a huge ball and we were in the middle. (Actually it is the earth that turns.)

We see different stars at different times of the year. (This is because the earth is travelling around the sun and so changes its position in space.)

### *(4). The 'twinkling' of stars*

The stars appear to 'twinkle' because the beam of light from such a distant source is very thin, and so movements of the air cause the beam to move.

### *(5), (6) and (7). The sun and the planets*

The chief aim is to give a picture of our earth as one of the sun's family. While it will be interesting to mention all the nine known planets, there is no need for the children to memorize all their names; they might memorize the four planets which can *easily* be seen, viz: Venus, (Earth), Mars, Jupiter, Saturn, together with a few interesting facts about each. Appeal to the children's imagination by telling them about conditions on the planets, but avoid making them learn facts and figures about their size and speed of revolution. Try to arouse interest in finding planets in the night sky, and notice that a planet changes its position with reference to the 'fixed' stars.

### (*8*), (*9*) *and* (*10*). *The moon and eclipses*

Eclipses have often given rise to fear. They are, however, perfectly natural events, and astronomers can tell us beforehand the day and the very minute at which an eclipse will begin and end. We are not alarmed when the sun seems to disappear in the evening: if eclipses were equally frequent they would alarm nobody.

*Practical work*

*a.* Demonstrate *the phases of the moon* if you can darken the classroom. For the sun use a strong electric torch; fix or hold a

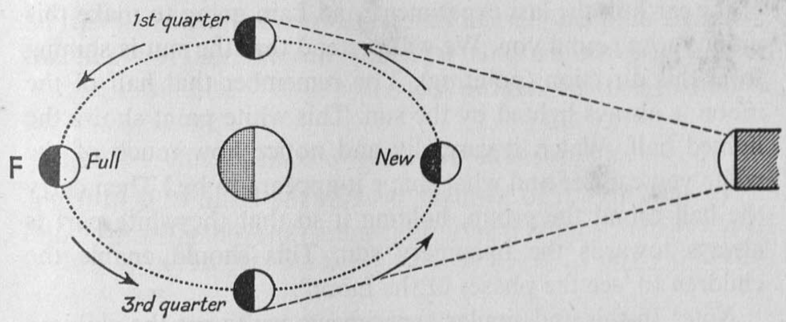



FIGURE 52.—An electric torch and a ball used to demonstrate the phases of the moon

short collar of cardboard or brown paper so as to make a little tube projecting *slightly* beyond the glass; this will help to give a level beam of light. If you cannot get a torch, use a candle. A child will represent the earth. The moon is a white-washed ball or fruit mounted on a sharp stick, with the 'man in the moon' drawn on one side. Tell the child who carries the moon to hold it up, otherwise you will get eclipses which are not wanted. The teacher must stand as far away as possible and keep the beam of light directed on to the 'moon-ball'. It is best to start from position F in Figure 52. The child in the centre must describe what HE sees of the bright portion of the 'moon'. Figure 52 is

drawn as if viewed by an observer somewhere outside in 'space'; this is what the rest of the class will see, and the only thing that may be clear to them is that the moon is always half dark and half light. An effort of imagination is required to picture what the ball looks like from *inside the circle*.

This difficulty can be overcome if the following demonstration is carried out:—

*b*. Make sure that the children have clearly realized from the last experiment that *one half of the moon is always lighted by the sun*. Use a ball or other spherical object which has one half painted white. Take the class outside and let them sit or stand in a group. Say: 'Now you are ALL going to take up the position of the earth in the last experiment, and I am going to make this moon move round you. We will pretend that the sun is shining from this direction (pointing). You remember that half of the moon is always lighted by the sun. This white paint shows the lighted half. Watch it carefully and notice how much of the white you can see and what shape it appears to be.' Then carry the ball round the group, holding it so that the white part is always towards the imaginary sun. This should enable the children to 'see the phases of the moon'.

*Note:* In this and similar experiments try to get the children to think of the real earth, sun and moon, not just of the little models in the classroom. Discuss with them what is wrong with the apparatus, e.g. the light used for the sun is much too small; it ought to be much farther away, and then there would be no need to keep moving it as the moon moves.

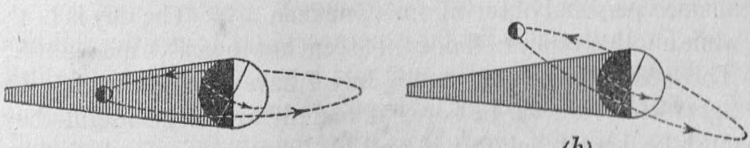
Discussion may arise on the subject of night and day. If the 'moon' pauses at each of the four positions shown in the diagram, the 'earth' should then turn round to show one night and day. The children will then begin to understand why we see the full moon at night, but not in the middle of the day, while the crescent moon is visible high in the sky in the day time.

*c. Eclipse of the moon*. Darken the classroom and use a source of artificial light.

Bring two fruits, a large and a small one, mounted on sharpened sticks. Let a child hold up one fruit: Why can we see it? Light from a source of light shines on it and is reflected to our eyes. Pass any object between the light and the fruit. Why do we no longer see the fruit clearly? We may either answer that the object has stopped the light from reaching it or that a *shadow* has fallen on it. (In a simple classroom experiment the ball will not be invisible because a certain amount of light will reach it by reflection from the walls, etc.)

Now let the larger fruit represent the earth, and make the smaller fruit revolve round it so that the earth's shadow falls on the moon. Repeat the movements and notice that as the moon enters the earth's shadow it seems as if a small piece had been taken out of one side. Gradually the moon moves further within the shadow until it disappears, but soon it begins to re-appear on the other side.

Let the class explain why an eclipse always occurs at full moon. Probably somebody will ask why there is not an eclipse at every full moon? A simple demonstration will explain this point. Mount a very small fruit or large bead on a circle of stiff



(a) (b)

FIGURE 53.—Showing why the moon is not eclipsed every month

wire; show that, if the moon revolved round the earth as in Figure 53(*a*), we should get monthly eclipses. But because it revolves as in Figure 53(*b*), the moon is usually just too high or too low to pass through the shadow.

*d. Eclipse of the sun.* Revise the elementary point that, when the shadow of an object falls on our eyes, the object is between us and the sun, so the sun is hidden from us. Use the same apparatus as in the last experiment and show how the moon may cast

a shadow on the earth. Usually the moon passes between the earth and the sun either too high or too low for the three bodies to be in a straight line; sometimes the moon covers a part of the sun only, causing a partial eclipse, more rarely it comes exactly between us and the sun and then we get a *total eclipse*, which is a very interesting event and enables us to see huge flames shooting out from the sun.

### *Weather*

The children kept very elementary weather charts when they were in lower classes. In some schools weather observations are kept in all classes. This plan has some advantages, but there is the risk that the children may lose interest. In any case they should now keep weather records in a more complete form. As an introduction there could be a discussion on 'weather', in which the following questions are considered:—

*What do we mean by weather?* There is no need for a definition; draw up a list of things included under the term, e.g. temperature, sunshine, clouds, wind, rainfall, thunderstorms.

*What is the value of weather records?* We cannot depend on unaided personal observations. One man says: 'The day is hot', while another replies: 'It does not seem hot to me.' A man states: 'This *seems* to me the wettest July I have ever known.' Is he right? How can we be sure? If records are to be useful they must be kept regularly; if possible, show some made in the school during previous years.

*What measuring instruments do we need for keeping simple weather records?* Mention the thermometer and rain-gauge, and possibly also the wind-vane and barometer. The last may not be obtainable, so the teacher may just refer to the great importance of measuring air pressure, revising what was learnt in the Fourth Year about the pressure of the atmosphere.

*Can we foretell what the weather will be?* It is highly important in air travel to know what kind of weather is expected. Say something about the work of weather-forecasting stations. Their

forecasts are not *always* correct, but they are reliable enough over the next twenty-four hours to be valuable for the safety of aircraft.

*Practical work*

*a. Temperature.* Read the thermometer before morning school and either at noon or at 2 p.m. See that the thermometer hangs in a place where it is always in the shade, when used for recording shade-temperatures.

*b. Rainfall.* The school ought to have a rain-gauge; if it has not, make one or get one made.

*c. Wind.* Record its direction and strength.[1] The direction can be much better recorded if your school has a wind-vane, which might be made by a local craftsman.

*d. Cloud and sunshine.* These can be recorded by means of symbols.[1] The children may learn the four main types of clouds, but, since many clouds are intermediate in character, they may find it hard to decide on the precise type of cloud.

In the book referred to,[1] a very simple kind of weather record is suggested, and this will suit some schools; it is not easy to use such records for comparison with the results obtained in previous years, so here is a suggestion for more accurate records of temperature and rainfall. Children have little difficulty in understanding the idea, without any formal introduction to graphs.

*Temperature.* Use a sheet of ruled foolscap paper turned sideways, and rule horizontal lines $\frac{1}{4}$ inch apart; this will allow a temperature range of 30°, which is sufficient for many places in the tropics. If you cannot get foolscap paper, use sheets from exercise books. When you explain the chart to the class, using a blackboard illustration, they will soon begin to enjoy this careful recording, including the joining up of their marks with a curved line. They see how easily this record can be compared

[1] See *Weather* by R. C. Ellis in the 'Science at Work' Series.

at a glance with the one kept by another class for the same month of another year.

*Rainfall.* Use a similar chart, but, instead of the curved line, show the amount of rain by colouring in the vertical column to the required height. Draw the horizontal lines at $\frac{1}{2}$-inch intervals.

*Thunder and lightning.* No satisfactory explanation of these can be given without some knowledge of electricity, and this subject has not been included in the Primary course. Thunderstorms are interesting and important, however, and the teacher should be ready to answer questions about them. In doing so he can make these points:—

Thunderstorms usually occur when damp, warm air rises rapidly. Before a storm we notice a gentle, warm breeze blowing *towards* the oncoming storm clouds; often we see leaves carried up from the ground by it. Then, just before the rain begins, we feel a rush of cool air blowing down and *away* from the storm, and heavy rain usually follows. Rainstorms during which there are violent upward and downward currents of air may electrify the clouds in such a way that huge electric sparks are formed. Sometimes the spark jumps from one cloud to another; more rarely it jumps from a cloud to the earth. Still more rarely the lightning flashes upwards from the earth to a cloud. These electric sparks (or discharges) are what we call lightning. The lightning gives out very great heat as it passes through the air. What happens to air when it is heated? (see the work in the Fourth Year). The heated air expands so suddenly that it causes violent sound-waves, which come to your ears as the noise of thunder. When air expands suddenly we always hear a bang, e.g. when a motor vehicle has a 'tyre burst' or when it 'backfires'.

*Dangers due to lightning and how to avoid them.* Emphasize that *thunder* cannot harm us; the *noise* is quite harmless. Then impress on the class that most lightning is harmless because it is

due to electric sparks among the clouds, and these never cause damage. Trees, buildings and people are occasionally struck by lightning; the people may be killed or suffer from electric shock and burns. Lightning takes the shortest way to the earth, therefore tall trees and buildings which stand in an open space are liable to be struck. So do not take shelter under a solitary tree during a thunderstorm. Some buildings have *lightning conductors*, which are iron or copper rods with a sharp tip that projects above the roof. The rod leads deep down into the earth. Electricity passes very easily through metal rods, and so it is conducted safely to the earth without causing damage.

## MATTER AND ENERGY

### TOOLS AND MACHINES

Some very simple ideas about tools and machines were given in the Fourth Year work. Continuing from these we can extend the knowledge, but still keep the work very practical. Aim especially at teaching the children how to look after tools and machines. Any machine is the result of careful thought and craftsmanship, and it also costs money; too often it is spoilt by misuse and lack of care, when it might have lasted for many years. So it is more important at this stage to know how to look after a cycle, or a sewing-machine, than to understand exactly how it works. The children can, however, understand that tools and machines make use of the following:—

The *lever*; the *wheel and axle*; *gear wheels*; the *wedge* and the *screw*. (For the sake of completeness the pulley should also be included, but this has been omitted because most schools will have difficulty in arranging practical work with pulleys.)

In planning the work be sure to make full use of objects that are familiar to the children; for instance, a potter's wheel and a weaver's loom are machines, and in every village there are tools which illustrate the uses of the lever and the wedge.

*Note:* After reading some textbooks you may feel uncertain

about the distinction between a tool and a machine. In general the difference is clear enough; we all know that a hammer is a tool and a bicycle a machine. You are advised to keep to the commonsense definition of the difference between hand-tools and machines.[1] 'A tool is something which can be held in the hand and which is made in one piece; a machine has several parts each with its own particular work to do.' Things such as the wedge and the lever are often described as simple machines, i.e. machines consisting of one part only. For this reason tools are often examples of simple machines.

*Main ideas to be brought out*

(1) We do *work* when we move anything by pushing or pulling it. We use *force* in pushing or pulling.

(2) Tools and machines enable us to do more work, to work more quickly or more conveniently while using the same force.

(3) A *lever* is a bar which turns about a point called the *pivot* (or *fulcrum*).

(4) A gradual slope makes it easier to raise things. The *wedge* and the *screw* both make use of a gradual slope in helping us to do work.

(5) When one thing rubs against another there is *friction.* Friction produces heat, causes wear and noise, slows down movement.

Friction is reduced by oiling and greasing.

Friction, however, has *many uses* as well as the above drawbacks.

(6) Some *wheels* are used for making transport easy. Others are used in machines for many purposes, e.g. turning a small force at one point into a large one at another, or vice versa; helping to make a force act at a different point from where it is applied.

[1] *Machines*, by F. E. Joselin, in the 'Science at Work' Series.

### (*1*) *and* (*2*). *Work and force*

Discuss different types of *work*. Show that in each case there is *movement* and that to get movement something is pushed or pulled. For instance, the act of writing means that we both pull and push our pencil to obtain the correct strokes; we are doing work. When we run we push against the ground and against the air, and we pull on certain parts of our legs and arms in order to lift them. (In science such things as holding a heavy weight, or thinking, are not called work!) Then introduce the word *force*; we apply force when we push or pull; turning a wheel is a combination of pushing and pulling. Now ask the class if they remember some ways of making work easier. Tools and machines can make a small force give a larger push or pull. Thus Man can do work for which his own strength would not be sufficient.

### (*3*). *Levers*

Avoid a theoretical approach; if you teach about the three different types of levers the children are likely to get confused. By means of practical demonstration and numerous examples from daily life, make the children familiar with levers and their uses.

*Practical work*

*a*. Out of doors use a board resting on a block of wood to make a see-saw. Place a heavy weight (or the heaviest boy) on one end of the board. How can we use this lever to lift the weight? We can *push* or *pull* downwards on the other end; this is hard work; we can put a heavy weight on the end, then it would do the pushing for us, but we should have difficulty in raising it. So long as the pivot is at the middle of the board and the weight at the far end we are unable to do the work more easily. Now show how the work becomes easier if:—

1. The weight is moved nearer to the pivot.
2. The lever is re-arranged so that the pivot is not in the middle, but nearer the end which has to be lifted.

*b.* In the classroom you can show more accurately how distance from the pivot affects balance. Note that the lever is balanced when there is an equal pull on each side at an equal distance from the pivot.

The apparatus can be made from a ruler, a long nail and an upright piece of wood such as the side of a box; or else, if the boys do woodwork, they may make the apparatus, using a longer piece of wood as the lever and fixing it to an upright block. In either case take care to mark the exact centre of the lever; if using a ruler, you can burn a hole through it with a red-

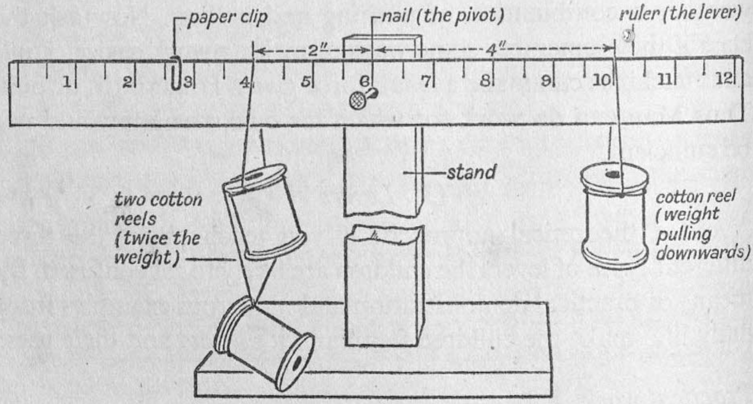



FIGURE 54.—A simple apparatus for showing the principle of the lever

hot wire or nail. See that the lever turns easily on its pivot, and get it to balance, so that it is horizontal, by placing a piece of wire (such as a paper clip) at some point on the lighter side.

Take three objects which are alike in size and weight, e.g. three empty cotton-reels of the *same make*. Suspend them by cotton threads; you will find that it does not matter if these are of different lengths. Show that two reels will always balance if hung at equal distances from the pivot. Now hang two reels from the same point and show that one reel will balance them if it is exactly twice the distance from the pivot (see Figure 54). Do this for several positions of the two reels.

*Conclusion.* A small weight can balance a larger one if it is further from the pivot; a weight balances another *twice as heavy* if it is *twice as far* from the pivot.

Note that the weights are *pulling* down on the lever. If the lighter weight is moved beyond twice the distance of the pivot, then it lifts the heavier weight, like a little boy lifting a big one on a see-saw. The lever helps us to do work: when we want a small pull to lift a very heavy weight we must have a very long handle to our lever; but notice that the weight will only rise a very short way, because we cannot get more work out of a machine than we put in.

*c.* Show, discuss, and use where possible, many examples of levers from everyday life.

You will need to point out that a lever is often bent.

Here are a few suggestions for examples:—

By means of a strong screwdriver open a wooden box which has been nailed down. Use the curved end of a claw-hammer to pull out a nail. Use a spanner to tighten a nut. Use scissors or tinsnips and show that these act as double levers. Show that a handle used to turn a wheel is like a lever. Find examples of levers on a bicycle, e.g. pedals, brakes and handlebars.

### (*4*). *Inclined planes; wedges and screws*

If you have a spring balance you can show very clearly that it takes less 'pull' to drag an object up a gradual slope than up a steep one. Illustrate this fact by referring to roads and paths in hilly country; when they wind from side to side they give an easy way up the hill, but note that the easier path is always longer than the steep, straighter one.

Then proceed to show that the thread of a *screw* is really a winding 'path' which gives a gradual slope. Great force can easily be exerted by turning a screw, because the gradual slope makes the work easy.

*Practical work*

*a.* Hang a small, heavy object from a spring balance. Measure the pull needed to drag the object up a board which is arranged to give first a gradual slope and then a steep one.

*b.* Let each child cut out[1] a triangular piece of paper (newspaper will do), about 3 inches high and 10 inches long; if he holds the paper as in Figure 55(*a*), he will recognize that side X forms a gradual slope. Keeping the paper in the same position, wind it round a pencil as in Figure 55(*b*). The slope X now forms what we call a spiral, that is, a winding, upward slope. Examine a screw: the thread forms a spiral like that made by the paper

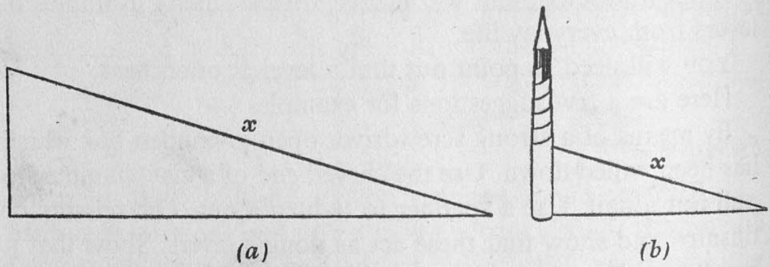



FIGURE 55.—A spiral is a winding upward slope

edge. Imagine a tiny insect crawling up the thread of the screw; it will be walking up a gradual slope. Take the paper off the pencil and cut[1] the triangle so that it is 3 inches high and 5 inches long. Note that the side X now forms a steeper slope. Then wrap the paper round the pencil: it now represents a screw with a 'steeper' thread, i.e. with the turns of the thread more widely spaced. Such a screw needs greater force to make it turn.

*c.* Visit the school woodwork room and also, if possible, a carpenter's workshop. Demonstrate the use of as many tools as possible, discussing their suitability for the jobs for which we use them. Look for examples of levers and gradual slopes. We make use of the gradual slope in all wedge-shaped tools

[1] Or crease firmly and tear.

such as the axe, chisel, knife, nail and also in the screw. Examine the large screw of a vice.

*d.* Visit any place where goods are weighed, and show how the weighing machine is used.

*e.* If you can borrow a screw-jack from a motor-car or lorry, show that a screw can be used to lift a very heavy weight.

### (5). *Friction*

This is an important subject. *Friction* has to do with rubbing: you have to do work if you rub two things together; if they are smooth the work is easy, for there is little friction; if they are rough the work is hard, for there is much friction.

There are many ways of showing that friction produces heat and causes wear: a few are suggested here:—

*Practical work*

*a.* Rub the hands together briskly. Hold a length of string and draw it sharply through your hand. Feel the striking surface of a matchbox. What produces the heat that lights the match?

*b.* Examine things used for sharpening tools, e.g. a hone and a grindstone. Most sharpeners have a rough surface, and all use friction to wear away rough places in the steel and produce a narrow, smooth cutting-edge. If you can watch a grindstone in use, notice that sparks may fly from it. Why does it dip into water?

*c.* Examine bicycle brake-blocks. What makes them wear out? Examine outer covers of lorry wheels. Why are badly worn tyres dangerous? Have you seen a lorry stuck on a muddy or sandy road with the wheels turning round and round because they cannot grip the slippery surface? Emphasize in this connexion that friction helps as well as hinders us.

Having shown clearly how friction produces heat and wears away surfaces, discuss the care of machines such as the bicycle and sewing-machine. Oil makes the surfaces slide easily and

reduces friction. (If the amount of oil in a motor-car engine is allowed to get too small, the engine is likely to become red-hot and so be completely spoilt.)

*d.* Examine a bicycle, sewing-machine or other machine, and look for 'bearings', i.e. places where there is movement of one part against another. Find out how to oil these machines.

### (6). *Wheels*

When teaching about *wheels* you need to distinguish between wheels which are used to lessen friction and so to make transport easy, and wheels which are used in machines to help us to do work.

*Practical work*

*a.* Fill a small box with stones and tie a string at one end. Pull it along the table. Now place under the box several pencils of the same thickness and notice the difference when you pull. If possible measure the difference in strength of pull by hooking a spring balance to the string. During discussion explain how only a part of the rollers is in contact with the table and thus friction is greatly reduced. Show that wheels are even more efficient.

*b.* An old clock enables you to show how the teeth of *gear wheels* fit into each other and make one wheel turn another. Show that a large wheel with many teeth will make a smaller wheel with fewer teeth turn more quickly (but in the opposite direction).

*c.* A bicycle enables you to show the effects of *joining gear wheels by a chain*; the two wheels now turn in the same direction. and the chain takes the force to a different place from the one where it was applied.

Make use, for further illustrations, of any machines or parts of machines that you can find.

## LIGHT

How do we get light? How does light help us to see? Why do we see reflections in mirrors? What is a magnifying-glass and why does it make things look bigger? Why are objects variously coloured?

Such are the kinds of problems that interest children. Note that they are concerned with how light *behaves*. Do not attempt to teach about the *nature* of light, although you must be ready to answer questions. (Remember that, as in other lessons, you may have to reply that you do not know, or that nobody knows, or that the topic is too difficult for study at this stage. Whenever possible, however, try to answer their questions in a way that the children can understand.)

### *Main ideas to be brought out*

(1) Light enables us to see.

(2) Things which give out light are *sources of light*. We see all other things because they throw back (reflect) light.

(3) The *sun* and *stars* are natural sources of light. Man makes many other sources of light for his own use.

(4) Light rays follow a straight path.

(5) A very smooth surface reflects light only in one direction; such a surface gives regular *reflections*.

(6) Some substances allow light to pass through them quite freely; they are said to be *transparent*.

(7) Light can change direction when it passes from one transparent substance to another.

(8) Sunlight is made up of light of different *colours*.

(9) The colour of an object depends on which kind of light it reflects.

### *(1). Light is necessary for vision*

Children at this stage are aware that light enables us to see

things, but there might be an interesting introductory discussion, including such points as:—

What enables us to see? (Light, which enters our eyes.)
Can we see at all at night? How?
What do we mean when we say: 'A cat (or an owl) can see in the dark?' Can they see in total darkness?
Do colours look the same by moonlight as by sunlight?
How are your homes lighted after dark? Can you mention other ways in which men obtain light?

*(2) and (3). Sources of light*

Link this with the lesson on the Sun and the Stars (see p. 190).

When reviewing artificial sources of light, some or all of the following may be discussed: flames from a fire; torches; candles; oil-lamps in which animal or vegetable oils are burnt; kerosene lamps; electric torches; electric light. The discussion will lead to the conclusion that many things give out light when they become hot. Most children have seen a blacksmith at work; the iron gives out light when it becomes red-hot. What are sparks?

The practical work which follows should make it clear that:—

(*a*) Fuels such as wax and oil must turn to gas before they can burn. All flames are made of burning gas.

(*b*) A bright, luminous flame contains particles of glowing soot.

*Practical work*

*a.* Study a burning candle. A steady flame is required: if there is a breeze blowing through the room, it will be necessary to arrange a draught-shield. Ask one member of the class to describe the top of the candle and the flame, in detail; draw what he describes on the blackboard. Ask other pupils to supplement where necessary, until all the points in Figure 56 have been included. Then interest the pupils in trying to discover more about how a candle burns.

*b.* Ask a pupil to light a candle which has not been lighted before. When he holds the match flame under the *tip* of the wick, why does the candle not light? Where must we put the flame so that the candle will light easily? Thus arrive at the conclusion that a candle-wick only burns to give a flame when it is soaked with melted wax, i.e. when the wax has turned to liquid on heating.

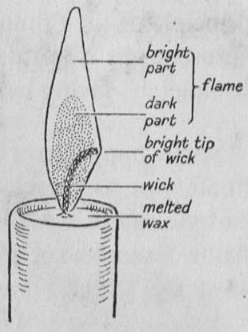



FIGURE 56.—The candle-flame

*c.* Show that the melted wax moves up the wick. Drop some fine particles of soot, from a used match, on to the pool of melted wax in the top of a burning candle: they will be drawn towards the wick.

*d.* Show that soot (carbon) is formed when a candle burns. Hold a plate in the yellow flame and look at the black deposit. Ask the pupils to describe and explain the black deposit on cooking pots, lamp chimneys and ceilings of rooms where oil-lamps are used.

*e.* Show that liquid wax does not burn; it only burns when it is turned into gas or wax vapour.

1. Put some wax on a tin lid. Hold a lighted match above the the wax (*a*) while it is still solid, (*b*) while it is liquid, (*c*) when some of it has changed to gas (wax vapour).
2. Blow out a lighted candle while holding a lighted match in your hand. Very quickly bring the match flame into the candle smoke. Can the class explain the fact that the candle lights again immediately? (There was hot wax vapour above the wick.)

*f.* Show that the dark inner part of the candle consists of unburnt wax vapour. Hold one end of a short glass tube in the dark part of the flame. Hold a lighted match to the other end. Unburnt wax vapour passes up the tube and burns with a flame.

*g.* Examine a lighted kerosene-lamp and note that it has the same essential parts as the lighted candle.

*h.* If the pupils are familiar with lamps which work on the principle of the Primus stove,[1] examine one of these. Here, too, kerosene *gas* is burnt, but as it is mixed with air it burns more completely, giving less soot.

Some pupils have seen carbide- (acetylene-) lamps used by hunters or as bicycle-lamps. In this case water falling on the carbide causes a *gas* to be given off, which burns with a bright flame. Examine such a lamp, if one is available.

### (4). *Propagation of light*

In the work which follows you will often refer to *beams of light*: make it clear that light is streaming out from luminous (light-giving) objects in all directions. A beam of light is just a small fraction of that light, and we often use beams of light in our experiments. Discuss beams of light which the children have seen, e.g. from the sun shining through a small gap between clouds; from car headlights; from a light in a room, through a door left slightly open at night; from a lighthouse. Note that all the beams are *straight*. Shadows provide another piece of evidence that light travels 'in straight lines'. Make a sketch of a tree and show the sun in the sky; now we want to draw the tree's shadow: how do we find exactly where the end of the shadow will come? This leads to a discussion of the fact that we cannot see round corners; if light could bend round we should be able to see round solid objects. In a later lesson we may find some way in which we can make light bend.

*Practical work*

*a.* Cover one window with strong brown paper; make a small hole in the paper and darken the room. If your room can be properly darkened you will get a good beam of light through the

[1] i.e. 'pressure-lamps'.

hole. Shake chalk, from the blackboard duster, in the beam, and notice how much clearer the beam becomes. Take this opportunity of explaining that we do not see light itself, we see objects which throw back, or reflect, light. Men have passed a beam of light through a glass box in which the air was quite free from dust; they could not see the beam from the side, because there were no dust particles to send back the light.

Show that the beam is straight by getting two pupils to stretch a piece of white cotton thread along it; tie each end of the thread to a large needle: otherwise the fingers of the boy will cast a shadow down the beam. When they pull the thread tight the whole of it is lighted by the beam; if they allow it to become loose, it bends and so is no longer within the straight beam.

*b*. Make sketches to show that the shapes of shadows depend on the fact that light travels in straight lines. Connect with the lesson on Eclipses (p. 191).

*c*. Make a *pinhole camera*, or, better still, get your pupils to make several. You need a box of tin or wood or cardboard, free from holes and cracks, about six inches long. If possible, choose one with the lid at the end, as you have to remove one end. In the middle of the opposite end make a small, clean, round hole, using a strong needle. Stand well away from a window and look at it through the hole, with your eye at the open end of the box.

Now cover the open end with a sheet of thin paper through which light can pass. ('Grease-proof' paper is the best kind. Fit it closely and fix it with string or a rubber band.) Now hold up your pinhole camera in the same way. What do you see on the paper screen? Light a candle and try to get a picture on the screen.

Can you explain what you see? Use your results to show that light travels in straight lines.

### (5). *Reflection*

It would be helpful to prepare for the lessons on mirrors and

reflections by asking the pupils to make observations at home. You might ask them to do the following:—

1. Make a list of objects in which you can see reflections.
2. Find out which things give the clearest reflection.
3. When you hold an object before a mirror, find out where the reflection appears to be.
4. Move the object further away from the mirror and notice what happens to the reflection.
5. Find out how you can hold the mirror so that you see objects in various positions in the room.

The class discussion will lead to the conclusion that we get regular reflections only from smooth, polished surfaces. Long ago men made mirrors of polished metal; later they learned to make glass mirrors. Examine a small mirror and note the red paint on the back and, next to it, the layer of mercury (quicksilver). By this time the children should be eager to know why we get reflections from polished surfaces and why the reflection appears to be behind the mirror. The practical work will help them to understand. The teacher must supplement it with clear diagrams.

*Practical work*

*a.* The children have probably done no formal work for which an understanding of *angles* is required. Explain angles by throwing a ball against the ground and noting how it rebounds in a different direction according to the angle at which it is thrown. Children who have played football, or have watched lawn tennis or table tennis, will have seen good illustrations of this fact.

*b.* Darken the room and obtain a beam of light as in Experiment *a.*[1] Let a mirror reflect the beam, using chalk dust to make it visible. Turn the mirror in different directions. Note that, when the mirror is perpendicular to the beam, the reflected beam goes straight back, so that only one beam is seen.

[1] Page 208.

Make diagrams to show that when a beam of light falls on a mirror at a certain angle it is reflected at the same angle (see Figure 57).

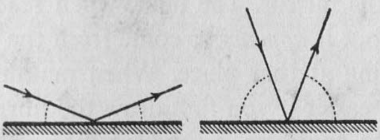


FIGURE 57.—How a beam of light 'bounces back' (i.e. is reflected) from a mirror

*c*. Show by a diagram (Figure 58) that a rough surface scatters light, while a smooth surface reflects it in one direction only. Hence we get regular reflections of objects from smooth surfaces. Let a child demonstrate how to polish any suitable article. Dust, grease and rust all scatter the light and spoil the reflection.

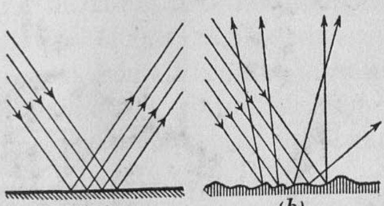



FIGURE 58.

(*a*) A smooth surface reflects a beam of light in one direction only
(*b*) A rough surface scatters a beam of light in many directions

*d*. Discuss the children's observations on mirrors, leading to the conclusion that the further away an object is from the mirror, the further behind the mirror does its reflection appear to be. Then do this experiment: you need a flat piece of glass, a candle and a bottle of water:—

Support the glass upright on a table and stand the lighted candle in front of it. Darken the room and let the children observe the reflection of the candle. Now place a bottle of water behind the glass and move it until the reflection of the candle appears to be inside the bottle. Measure the distances of

the candle and the bottle from the glass. Repeat with the candle in different positions.

Use the diagram in Figure 59 to explain why we seem to see things behind the mirror. The light which reaches the eye has been reflected, but it *appears* to come from the point R, and so we see something at that place. When making your diagram you will find it easier if you first draw the mirror and then the line OR at right angles to it, making OM = MR. Next draw a line from O to the mirror and then the dotted line from R to the same point on the mirror. If you continue this outwards, as the reflected ray, it will be at the correct angle.

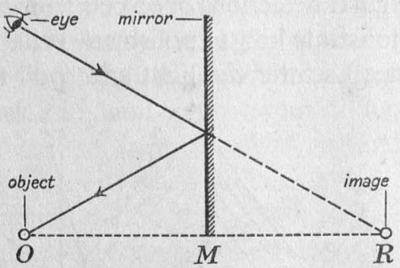



FIGURE 59.—To show how we see an image *behind* a mirror

*e*. Using the children's observations, discuss the fact that a mirror appears to reverse the right and left sides of objects. Examine in a mirror:—handwriting, print, a clock face. Write a word in ink and obtain a good 'reflection' of it on blotting paper. Hold the blotting paper up to a mirror: it shows ordinary writing again.

If the children can bring small mirrors to class, let each child, or each pair, hold one and try to write some capital letters while looking in the mirror.

### (6). *Transparency*

Explain the word *transparent*. Air, water and glass are transparent.

### (7). *Refraction*

The children are familiar with spectacles; the usual sun-glasses contain only flat pieces of glass; spectacles for the use of people whose sight is defective have pieces of glass with curved surfaces; these are called *lenses*. Magnifying-glasses, microscopes and telescopes all depend on the use of lenses. Without any explanation of how lenses work proceed to the following experiments.

*Practical work*

*a*. It is easy to show that a pencil appears to be bent at the point where it enters water. In a large class children will get a better view if you can bring a large pan and a straight board. Have some water ready in another vessel. Place the board as in Figure 60(*a*); pour a little water into the pan and look at the board; then pour in more water, holding down the board so

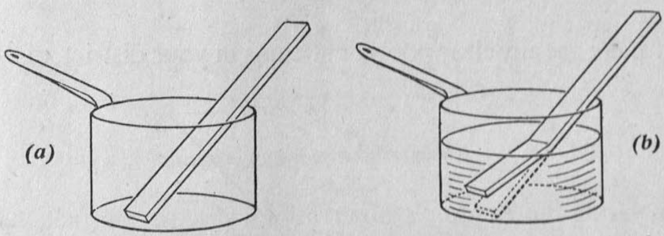



FIGURE 60.—How a board dipping into water appears to be 'bent'

that it remains in the same position as at first. Observe again. Then make sketches to illustrate the results. See if the class can write down the conclusion which they draw from this observation. (The board appears to be bent at the point where it enters the water, Figure 60(*b*).) This version of the experiment has the advantage that the board enters the water at the same angle throughout.

*b*. Hold a ruler upright in water. What do you notice about the part which is under water? You should look downward into the water through the surface, not through the side of a glass jar. Slowly raise the ruler. Ask what conclusion we can

draw? (The part which is beneath the surface appears shorter than it really is.)

*c*. Put a coin at the bottom of a bowl or pan. Let a pupil stand so that the side of the pan just hides the coin from sight.

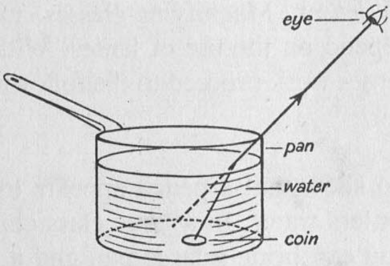



FIGURE 61.—Looking at a coin in water

Now pour some water into the pan; he can see the coin again (Figure 61). The pupils will probably try this for themselves at home.

If there are any clear pools or streams in your district, discuss

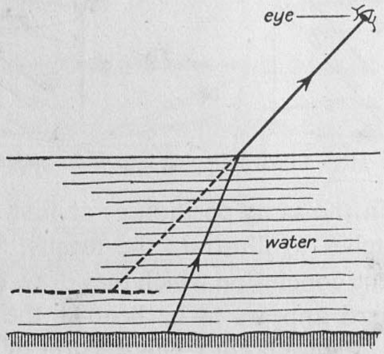



FIGURE 62.—A pool of water appears less deep than it really is

the fact that the bottom looks nearer the surface than it really is, hence the water appears less deep than it is (Figure 62).

*d*. If possible, demonstrate that a beam of light is bent when it enters water. Make a *narrow* beam, as before, and allow it to pass through water in a glass jar. Hold the jar at different angles

in the beam. (Show up the beam in the air by shaking chalk dust, and show it up in the water by adding a few drops of milk.)

Explain the above experiments with the help of diagrams. There are two important points to make clear:—

1. When light passes from air into water, or from water into air, it is bent, i.e. it does not continue in its former path.
2. When we look at a thing we always see it as though the light from it had come to us along a straight line. Hence, if the light has changed direction on its way to our eyes, the object appears to be in a different position from its true one.

Light is also bent when it enters and leaves glass: spectacles and magnifying-glasses depend for their action on this fact. Differently shaped lenses bend the light in different ways.

*e.* Use a magnifying-glass to focus the sun's rays on a thin piece of dry paper. The paper becomes black and may even catch fire. Show with a diagram how the rays are bent on entering and leaving the glass (Figure 63). Explain the term 'focus'.

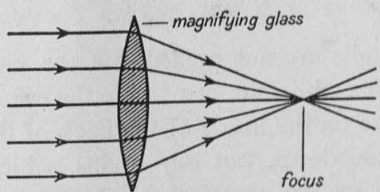



FIGURE 63.—How a lens 'bends' rays of light:—the magnifying-glass brings the sun's rays to a *focus*

*f.* If possible allow the children to examine things with a magnifying-glass. Use the diagram in Figure 64 to explain why the object looks larger, and why they should put their eyes near to the glass when using it.

If you cannot get a magnifying-glass, you can show a striking example of magnification by holding a ruler vertically in a round glass jar full of water; look through the side of the jar.

Tell the children something about the microscope and telescope and their uses.

*g.* Hold a piece of white paper against the wall opposite to a window; hold a magnifying-glass a short distance away and obtain an upside-down picture of the window. You can also

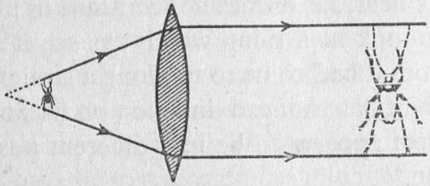


FIGURE 64.—The use of a lens for magnification. (The tiny insect is at the focus of the lens; an eye put near the lens sees a clear, enlarged, upright picture)

darken the room and get an upside-down picture of a candle flame. By means of a diagram, show that at the focus of the lens the rays cross, and so the picture is upside down. You can show an upright picture, less clear than the first, by holding the glass near to the paper. Can the class explain this?

## *The eye*

Anatomical details are not needed, but the children will now be able to understand that just inside the eye is a lens, which throws a picture on the inside of the back of the eyeball. This picture is upside down, but our brains, which interpret the pictures, make us 'see them' the right way up. We cannot explain at this stage how this is done.

In some people's eyes the lens cannot be properly focused so as to get clear pictures. Their eyesight should be tested by a doctor, who will be able to find out exactly what shape of spectacle-lens they need in order to correct the fault. Spectacles which are right for one person are usually wrong for another, and it is very important to use only the right ones. Examine a few different pairs of spectacles and note that the lenses are curved.

### *(8) and (9). Colour*

You cannot give a clear demonstration of how light can be separated into the colours of the rainbow unless a glass prism is available. You can discuss *rainbow colours* as seen on oil films, on soap-bubbles, at broken glass surfaces, in rainbows, and when the sun shines on spray from sea waves or a waterfall. An explanation of how the rainbow is caused is too difficult at this stage, but the teacher can say that the tiny drops of water reflect the light back to our eyes in such a way that it is separated into the different colours. White light consists of the seven colours combined; coloured objects separate out only one kind of light and send this back to our eyes. A red object takes in all the light *except the red*; it reflects the red light.

*Practical work*

*You can only carry out these experiments successfully if you have clear, pure colours.*

*a.* Cut circles of white cardboard (paste white paper on your cardboard if it is not white). Paint the two halves of the card different colours, e.g. red and blue, or blue and yellow,

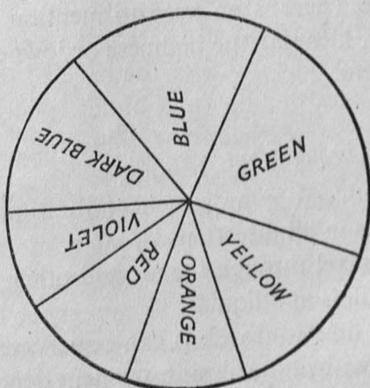



FIGURE 65.—The 'colour-wheel'. (Try to make the wheel with colours in the proportions shown)

or red and yellow. Push a piece of wire through the centre of each card. Spin the card rapidly on the wire. Record the colour which you see when each pair of colours is combined.

*b.* Using the same method as in Expt. *a*, copy the colours indicated in Figure 65. Make the card revolve while holding it in bright sunlight. You may not be able to obtain pure white, because (*a*) you cannot keep it revolving rapidly enough; (*b*) your individual colours may not be 'pure'; and (*c*) your coloured segments may not be correctly proportioned.

## SOUND

We learn about the world around us mainly by seeing and hearing; we communicate with other people mainly by talking. Most of us enjoy singing and listening to music. Hence children want to know: What is sound? How is it produced? How do we hear? How can we obtain different notes on musical instruments?

The answers to most of these questions are very complicated, but we can give some general ideas about sound, how it is produced and how it travels, without going into details which are too difficult for children. Do not try to explain about types of wave motion. There is no need to mention frequency; but the word 'pitch', meaning the highness or lowness of a musical note, will be useful.

### *Main ideas to be brought out*

(1) Sound is produced by movements (vibrations).
(2) Sound travels in all directions.
(3) Sound can travel through the air and other gases, and also through solids and liquids.
(4) Sound takes time to travel. It can be reflected.
(5) The note given by a musical instrument depends on the size and shape of the part which vibrates. It may also depend on how tightly a string or wire is stretched.

### (*1*). *Vibrations*

Through discussion of the children's own experiences, lead them to appreciate that, when there is a sound of any kind, something has *moved* to produce it. How difficult it is for the thief to move without making a sound! Consider various sounds, and in each case think what moves: e.g. the sound of moving water, of rapidly moving air, of moving birds' wings; the buzzing of an insect in flight; the sound from the sawing of wood; the beating of a drum. Contrast the sound of any machine in motion with its silence when at rest. Even a movement which appears silent to the human ear may be heard by an animal such as a dog.

Now show that sound is produced by a particular kind of movement. When something moves to and fro rapidly it is said to vibrate. Sound is caused by *vibrations*. A vibrating object causes the air around it to vibrate. When vibrations of the air reach our ears we hear a sound.

*Practical work*

*a.* Take a table-knife and hold the handle firmly on the edge of a table, as in Figure 66. With your other hand push the blade

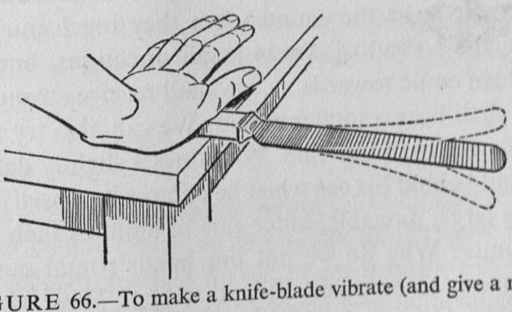


FIGURE 66.—To make a knife-blade vibrate (and give a note)

down hard and then let go. The knife vibrates and produces a humming note. The class may have to come up in small groups in order to hear the sound.

*b.* A solid which does not bend can be made to vibrate. Hang

up a piece of iron such as is used by many schools in place of a bell. Strike it and it gives out a particular note; this is caused by the vibrations of the iron itself and has nothing to do with the slow swinging motion. Feel the iron just after striking it. The vibrations can be felt, but your touch stops them and stops the sound too. Compare a bell such as a bicycle-bell with the iron; a slight touch again stops the vibrations and the ringing.

*c.* Let the children feel their throats while speaking. Tell them about the cords in the voice-box.

*d.* Demonstrate any stringed musical instrument and pluck the strings. Discuss other musical instruments and find out what it is that vibrates in each.

### (2). *How sound travels*

When we drop a stone into water, waves travel out in all directions at equal speed, and so we get circles of little waves. The waves are stronger (that is, higher) near where the stone falls; gradually they become weaker as they travel farther. When anything vibrates waves travel out through the air in all directions, becoming weaker as they travel, until they become too weak for us to hear the sound when they reach our ears. By preventing the spread of waves in all directions, and making more of them come towards us, we shall receive stronger vibrations and shall hear a louder sound. We can also try to collect more of the waves in our ears. Why does a slightly deaf person put his hand behind his ear when he cannot hear well? Of what use are the large, movable, outer ears of animals such as horses and elephants? Why do we put our hands round our mouths when shouting to someone at a distance? Have you seen a megaphone?—How does it help the listeners to hear what the announcer says?—Does it help or hinder the hearing of people seated behind the announcer?

*Practical work*

You need a tube 2–3 feet long. To make one take a sheet of newspaper. Completely cover one side of the sheet with paste, and roll it round a stick. After a few minutes take out the stick and leave the paste to dry.

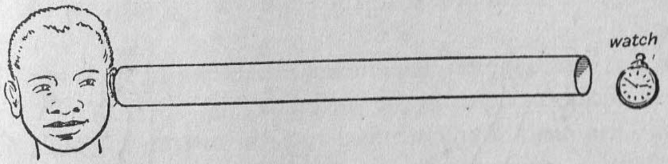



FIGURE 67.—A 'listening-tube'

Put a watch on the table. Measure the greatest distance from which one pupil can hear the watch ticking. Now let him put the tube to his ear and put the other end near the watch. Measure the distance from which he can now hear it. The tube prevents some of the waves from spreading out, and so stronger waves reach the ear.

(3). *Sounds can travel through solids, liquids and gases*

Sound travels well through many solids because the solid itself vibrates. Sound also travels in liquids, but it is not easy to give classroom illustrations of this.

*Practical work*

*a.* Show that sound travels along a tighly stretched string. If you can supply plenty of string, divide the class into small groups and let each group do one of the following experiments:

Stretch a long string *tightly* between two pupils. Let one hold his end of the string in his ear and let the other scratch the string with his finger nail.

Tie a spoon, preferably a large one, in the middle of a piece of string about 5 feet long. Press the ends of the string into the

ears and swing the spoon so that it knocks against something hard.

Make a string 'telephone' from two small tins with a hole pierced in the bottom of each, and a long piece of string joining the two (see Figure 68).

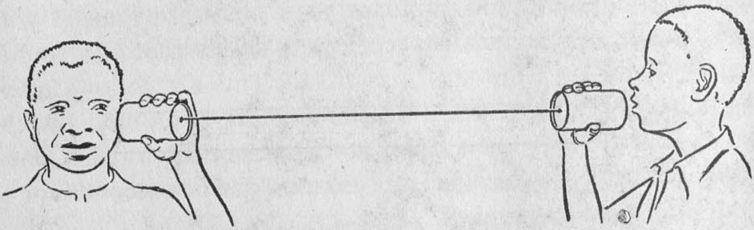


FIGURE 68.—A string 'telephone'

*b.* Ask the children to think out other ways in which they can show that sound usually travels better through solids than through air. They should all try putting an ear to the ground to listen for some distant sound, e.g. the noise of a lorry or a trotting horse.

### (4). *Echoes*

Echoes are an interesting result of the fact that sound can be reflected. Some schools have a wall that is high enough and long enough to give echoes to sounds made more than 50 feet in front. A high rock face or cliff gives the best echoes. Children who live in mountainous regions will know how thunder seems to go from one side of the valley to the other; it is 'sent back' (or reflected) by the mountains.

#### *Practical Work*

*a.* If you can find a place that gives an echo, take the class there. Start near the wall and go backwards until you get an echo when you shout 'One'. Measure the distance from the wall by pacing. Do not allow any of the pupils to stand between the one who is calling and the wall. Go back twice the distance and try if you can get a double echo when you call 'One, two'.

Discussion should bring out the two facts which echoes illustrate: (i) sound can be reflected; (ii) sound takes time to travel, for we have to wait while the echo comes to us. Discuss other ways in which we can tell that sound takes time to travel: e.g. when a gun is fired at a distance we see the flash before we hear the noise. If you watch a man hammering metal you can, if you are some distance away, notice that the sound reaches you *after* the stroke is made. Thunder follows after lightning; both arise from the same cause, but sound travels much more slowly than light. Sound travels at roughly one-fifth of a mile per second, i.e. it takes about five seconds for a sound to travel one mile.

*b*. Find out how far away a thunderstorm is, by counting slowly from the time that you see the lightning flash until you hear the thunder. Reckon one mile for each five seconds. If you give the class a little practice in counting at the speed of one a second, they will be sure to do this bit of practical work out of school.

(5). *Musical notes*

Base the work on those musical instruments which are familiar to the children. We may distinguish the following types:—

1. Instruments of the *xylophone* type. Vibrations of flat pieces of wood or metal of varying sizes give notes of different pitch.

2. *Stringed instruments*. Long, thick strings give deeper notes than shorter, thinner strings of the same material under the same tension. Hence we can make an instrument with several strings of the same length and tightness, but if they are of different thicknesses they give different notes. Then we can make any one string give out a great variety of notes by pressing it at different places. When we press the string it is just as if we shortened it, for only the part above where we press will vibrate. The player of such an instrument learns, after much practice, exactly where to press the strings so as to produce the notes he wishes.

The pitch of a particular string can also be altered by stretching it more tightly, or by loosening it; this is called 'tuning' the instrument.

3. *Wind instruments.* All of these have a tube of some kind, and the air in the tube is made to vibrate. There are different ways of changing the length of tube in which the air is set vibrating. In simple pipe instruments there are holes which can be uncovered: the air escapes through the hole and so a different length of the tube is used.

4. *Drums.* A stretched skin is used. Most drums can be tuned by tightening or loosening the skin.

THE HUMAN VOICE resembles a wind instrument rather than one with strings, even though the vibrations are started by the movements of strings. As we breathe out, air from the lungs can be forced through the voice-box, causing the vocal cords to vibrate. These set the air in the upper throat, nose and mouth vibrating. Feel the throat while you sing first a low note and then a high one. You can feel the vibrations; you can also feel the contraction of the muscles which tighten the cords to give a high note. Why are men's voices lower pitched than women's?

THE EAR. Give only a very general outline. The important points are:—

The tube of the ear is closed by a very thin sheet of skin, the ear-drum. Sound waves cause this to vibrate. The vibrations are carried, by a little bridge of three tiny bones, across to the inner ear. The inner ear is right inside the bones of the head, very well protected; in it the vibrations are changed into nerve signals which go to the brain, and then we hear sounds.

There is a passage from the middle of the ear to the back of the throat. Sore throats and bad colds may start ear infections through this tube, and this may lead to deafness.

The outer ear is of little, if any, practical use in hearing.

The ear-drum is very delicate and may be injured. Refer to 'the Care of Ears' in the work of the Fifth Year.

APPENDIX A

# A List of Materials needed for the Practical Work in this Book

1. *Materials that may be collected or made locally*

Tins: cigarette tins and larger ones
Glass jars
Glass bottles
Flat tins or boxes for growing seeds
Flower-pots
Saucers
Boxes (of cardboard or wood)

Cardboard: from boxes or backs of writing-pads
Newspaper
Brown paper
Mosquito netting (small pieces)
Pieces of string
Pieces of wire
Rubber bands [1]
Old inner tube (bicycle or car)
Candles: short pieces
Razor-blades (old)

Clay
Sand
Sugar
Starch
Lime (= whitewash), very small quantity

Old clock

[1] Quite a useful band can be made from a thin strip of inner tube (from the next item) cut or tied to form a ring.

Gear-wheels
Clock-spring

Small mirrors or bits of mirror
Kettle
Teapot
Large pan or bowl
Water cooler (earthenware)
Electric torch
Hammer
Nails
Screws (large and small)
Screwdriver
} These can probably be borrowed

Metal funnels about 3–4 inches in diameter
Rain-gauge
Shadow stick (small portable type)
Charcoal stoves
Box-type cages

Home-made scales
Home-made spring-balance
Set of weights, perhaps home-made
} These are very useful but not essential

2. *Materials that must usually be bought*

Spring-balance
Magnifying-glass: several if possible.
Glass tubing—soda-glass, 5 mm. diam.—2 lb.
Rubber tubing (bunsen burner type)—5 mm. diam.
Thermometer
Corks: 1 doz. assorted
Cork borer: set of 3
Triangular file
Set of weights: 2 lb., 1 lb., 8 oz., 4 oz., 2 oz., 1 oz.
Alcohol or methylated spirits
Iodine solution
Charcoal

Blotting-paper
Sheets of strong brown wrapping-paper
Cotton-wool
Cotton thread
Pins
'Gloy' or other adhesive

APPENDIX B

# List of Books

The letter in brackets shows the country of publication:—

**(A)—United States of America** **(B)—Great Britain**
**(F)—France (French language)** **(S)—South Africa**

Books marked with an asterisk (*) are useful for the upper, rather than the lower, primary classes.

### 1. HELPFUL TO TEACHERS AND PUPILS

*From the African Welfare* Series. Oxford University Press (B)
*Water and the Land*. CLEMENTS & TOPHAM
*The African and His Live-stock*. THORNTON & LECKIE

*Basic Science Education* Series. Row, Peterson Co., Evanston, Ill. (A). PARKER

*Basic Studies in Science* Series*. Scott Foresman Co., Chicago (A). BEAUCHAMP & others

From the *Science at Work* Series. Oxford University Press (B)
*Insects and Disease*. EDNEY
*Machines*. JOSELIN
*Weather*. ELLIS

From the *Science in the Modern World* Series*. Longmans, Green, Cape Town (S). FLOOD
*The Air Around Us*
*The Earth on which We Live*
*Machines and Engines*
*The Wonders of Light*

*Scientific Living* Series*. Singer & Co., Syracuse, N.Y. (A). FRASIER & others

From the *Simple Science in Simple English* Series. Oxford University Press (B)
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*Some Tropical Plants and Their Uses.* IRVINE
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*The Plague of Locusts.* BURR

*Steck Science* Series. Steck Publishing Co., Texas (A). HUDSPETH & others

*Understanding Science* Series. John C. Winston Co., Philadelphia (A). DOWLING & others

*Wonderworld of Science* Series*. Chas. Scribner's Sons, New York (A). MEISTER & others

*A First Tropical Nature Study.* DEAKIN. Longmans, Green (B)

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*Experiments in Science.* BEELER & BRANLEY. T. Y. Crowell Co., New York (A)

*Fun with Science.* M. & I. FREEMAN. Random House, New York (A)

*Health Science for Tropical Schools**. DANIEL. Oxford University Press (B)

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*Leçons de Choses.* BOULET & CHABANAS. Librairie Hachette, Paris (F)

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*Leçons de Science**. PASTOURIAUX & RÉGNIER. Librairie Delagrave, Paris (F)

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*Let's Find Out.* N. & H. SCHNEIDER. Wm. R. Scott Inc., New York (A)

*Mon Premier Livre de Leçons de Choses.* PASTOURIAUX, LE BRUN & BLIN. Librairie Delagrave, Paris (F)

*Pathways in Science.* CRAIG & others. Ginn & Co., New York (A)

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*Teaching Science to Children*. GREENLEE. W. C. Brown Co., Dubuque, Iowa (A)

*The Outdoor World* (6 books). SKAIFE. Longmans, Green (S)

*Without Fire*. BAER. Rinehart & Co., New York (A)

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*Handbook of Suggestion for Teachers*. Board of Education. H.M. Stationery Office, London (B)

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*Science in Childhood Education*. CRAIG. Columbia University, New York (A)

*Teaching Elementary Science*. BLOUGH & BLACKWOOD. F.S.A., Office of Education, Supt. of Documents, Washington, D.C. (A)

*Note*.—Every teacher should keep a keen look-out for suitable books. It may be possible to obtain simple text-books, or readers, written in the children's own language and based on local conditions.

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